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MALAYAN AGRICULTURAL JOURNAL

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Kuala Lumpur.

PRICE $2

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THE

Malayan Agricultural Journal

JANUARY, 1952.

EDITORIAL

Oil Palms. This issue of the Journal contains two articles on oil palms by Mr. R. B. Jagoe, Acting Chief Research Officer. The first article puts on record all the available information on the introduction of the oil palm into Malaya and the history of the "Deli" palm. The second article describes the selection and subsequent history of the "Dumpy Deli" palm and its progeny.

There are few readily available records of the early introduction of oil palms into Malaya and it is surprising that even as late as 1912, although there is record of the planting of "Deli" palms in Kuala Lumpur, there is no record of their origin. In his first article, Mr. Jagoe discusses the various opinions given as to when the first oil palms arrived in the East Indies and from where they came.

In the second article, the history of the original "Dumpy" palm and its progeny is described and the palms are compared with normal "Deli" palms.

It is obvious that with the difficulty in obtaining labour and its probable effect on the cost of harvesting, it will be a great saving to estate owners if they possess "dumpy" palms of equal yielding capacity to normal "Deli" palms but which can be harvested from the ground. The majority of the selfed "dumpy" palms have the defect of a rather low percentage of good fruits per bunch when compared with the best normal palms, but bunches are large and the defect is not common to all "dumpies" so that officers of the Department are confident of eliminating this defect by breeding.

As the difficulty of harvesting on tall palms is a major factor determining the economic life of oil palms, the low growing "dumpies" are likely also to make another valuable contribution to the industry in extending the periods between replantings.

Gelam Soils. In the third article in this issue, Mr. Coulter, of the Soils Division, discusses the occurrence and characteristics of *gĕlam* trees and *gĕlam* soils in Malaya.

It has been the experience of padi growers in some areas that their crops often fail when grown on *gĕlam* soils, but on the other hand, in some *gĕlam* areas cultivators have grown fair crops of padi without deterioration of yield.

Mr. Coulter also discusses investigations that have been carried out in connection with the sulphur content of these soils and indicates ways and means of decreasing the toxicity of soils containing sulphur.

Reports on Mechanisation. In view of the fact that the Department is now importing fewer items of mechanical equipment, it has been decided that the Report on Mechanisation should appear half-yearly instead of quarterly. The report will be published in the April and October issues of the Journal.

"DELI" OIL PALMS AND EARLY INTRODUCTIONS OF *ELAEIS GUINEENSIS* TO MALAYA

BY

R. B. JAGOE,

Acting Chief Research Officer.

Introduction.

Whether the West African oil palm, *Elaeis guineensis,* is an indigenous African species or an introduced one is a matter of debate, for, although it is widely established, as its name implies, in tropical West Africa, the genus is much better represented in South America; indeed this latter region contains nearly all the *Cocoineae,* to which order *Elaeis* belongs. It is, however, very well established in the tropical zone of Africa, and is of importance in the peasant economy of that region.

As a perennial and a high producer of oil it is one of the most suitable and important oil-crop plants for the tropics. Under plantation conditions in Sumatra and Malaya, palms come into bearing at 4 or 5 years from planting, reach full production at about 9 years, and continue to bear crops of 16 to 25 cwts. per acre for another 20 years, increasing in height of stem, after the first four years of girth development, at the rate of approximately 18 ins. per annum.

The African oil palm is well known to anyone likely to read this publication, and there is no need to give a description of a typical specimen. It is one of the larger species of palms, but has not quite as fast a rate of growth as the coconut palm. It retains the bases of the leaf frond petioles on the trunk for many years. Average girth at 3 ft. from the ground, and including the closely adhering petiole bases, is 7½ ft.

There is, of course, considerable variation in the rate of growth, in diameter of the stem, and in other characters.

Fruit Types.

Separate (occasionally composite) male and female inflorescences are produced in the axils of the large fronds; and the large bunches of oil palm fruits are composed of several hundred plum-like individuals, usually orange-red in colour. These fruits are constructed of an oily outer fibrous covering or pericarp, a hard shell, and a hardish oily kernel or seed. The pericarp produces the better known palm oil of commerce, but the kernels also produce a palm kernel oil, similar to coconut oil, and palm kernel cake.

There are variations in the amounts of the three components of the oil palm fruits, and palms have been primarily classified on the amount of shell in the fruit. The more common West African palm has very thick-shelled fruits (approximately 60 per cent. shell) and is referred to

as "macrocarya" form ("Congo" type); less thick-shelled fruits (approximately 30 per cent. shell) are known as "dura" form, and here belongs the "Deli" type. There are also palms with shell-less fruits and very small kernels—"pisifera" palms—but the fruits are usually infertile; and there are thin-shelled or "tenera" type palms, which are unstable hybrids of the thick-shelled and the shell-less forms.

In general, the thicker the shell the thinner is the valuable oil-bearing pericarp, and it is unfortunate that the shell-less and thin-shelled forms are highly infertile or unstable.

There also are palms on which the fruits have a "mantle" of oil-bearing pericarp due to the presence of six accessory sterile carpets. This type of fruit might be useful in development of high percentage of pericarp, but has a disadvantage attendant on irregular pericarp ripeness.

There are also palms with green-coloured fruits.

The "Deli" palms, commonly grown in Sumatra and Malaya, have a comparatively high rate of production of fruit bunches; also, in general, the fruits, although of the moderately thick-shelled type, have a high percentage (approximately 60 per cent.) of pericarp compared with average West African fruits. When "Deli" palms are now referred to, it is palms with this medium thickness of shell and relatively high percentage of pericarp which are inferred. It would be of interest to know to what extent the seed of the original palms was fortuitously or otherwise selected.

Oil Palms in Indonesia.

Oil palms are known to have been growing in Mauritius and Calcutta in 1836, and the earliest record of the introduction of oil palms to the East Indies is of four seedlings, two direct from Mauritius and two via Amsterdam, planted at the Botanic Gardens, Buitenzorg (now Bogor) in 1848.

Distribution of seed of these palms commenced about 1853 and, in 1859, Netherlands East Indies Government plantations of 14 acres at Banjar Mas in Java, and of 3 acres at Palembang in Sumatra were established for experiment purposes but were later abandoned. In 1878, one acre of oil palms was also planted in the Economic Gardens at Buitenzorg for further observation and experiment.

There is some confusion as to subsequent history in Sumatra, but some time about 1874 to 1875, seed was sent from Buitenzorg, and in 1879 the general manager of Deli Maatschappy reported to Buitenzorg that young palms were growing well near Deli. In 1884, palms were planted in an ornamental avenue on St. Cyr Tobacco Estate not far from the same Deli neighbourhood, and on Bekalla Estate in 1888, and subsequently, in 1898 and 1903 and later, small groups and avenues of palms were planted on St. Cyr, Bekalla, Tandjong Morawa and several other estates.

Some reports give Singapore as the origin of the seed first planted on St. Cyr Estate, but Rutgers doubts this as seed could have been obtained

so much more easily from the Deli Maatschappy palms. Moreover, there is no record in the Botanic Gardens, Singapore, of any seed having been sent to Sumatra, although palms were growing there at the time, for the first reference to oil palms in Malaya is that by Burkill of seed brought to the Botanic Gardens, Singapore, about 1870, probably from Java. It can hardly be doubted, therefore, that the St. Cyr palms were from seed derived indirectly from the original Buitenzorg palms, either through Deli or Singapore.

In 1910 to 1911, following a general increase in demand for supplies of vegetable oils, Mr. Hallet, a Belgian with knowledge of oil palms in West Africa, observing how well the palms grew in Sumatra, planted oil palms in the first large commercial plantation in Sumatra, using local seed. It is reported, by Burkill, that some interest was also shown in Malaya, in Johore, but no extensive planting resulted.

By the end of 1914, about 6,500 acres had been planted along the east coast of Sumatra. It is understandable that these palms were known as "Deli" palms, and as demand for seed increased, seed from the east coast of Sumatra was referred to as "Deli" seed in contrast to the generally much thicker-shelled seed from West Africa, which was usually referred to as of the "Congo" type.

A number of introductions of seed from West Africa was made by the Buitenzorg Gardens and by various commercial concerns in Sumatra, especially between 1912 and 1921, which proved to be largely of the "Congo" type of fruit, and subsequent selection work in Sumatra at first consisted of elimination of thick-shelled palms from seed gardens to avoid contamination of the established "Deli" type.

Oil Palms in Singapore and Labuan.

As mentioned above, there is a report of oil palm seed sent from Java to Singapore in 1870, but the nucleus of the present Botanic Gardens, Singapore, was developed by an Agri-Horticultural Society formed in 1859; Mr. Lawrence Niven, a planter by profession, was in charge of the Gardens in 1870, but there was no permanent paid supervisor until 1874 when the Gardens were taken over by Government and Mr. James Collins was appointed Economic Botanist. He left in 1875 and was succeeded by Mr. A. J. Murton, as Superintendent of Gardens, and he in turn, in 1880, by Mr. Cantley who extended the Gardens. Both Mr. Murton and Mr. Cantley introduced a number of new and useful species, but records of plant introductions are incomplete until 1888 when Mr. H. N. Ridley succeeded as Director of Gardens, after Mr. Cantley's death in 1887.

Bunting *et al* state that "The earliest record of the introduction of the oil palm into Malaya is in 1875, when seed was received at the Botanic Gardens, Singapore, from Peradeniya, Ceylon, probably through the Royal Botanic Gardens, Kew." It is possible that this is incorrect and may be a misquotation, as the first record at Kew of oil palms being sent from Kew to Ceylon is in July, 1875, when a Wardian case (of germinating seed or seedlings) was sent to the Botanic Gardens, Peradeniya. It seems

likely that some of this seed or seedlings were sent on to Singapore in 1875, or that, at any rate, any seed received in Singapore was from Kew via Ceylon, not Ceylon via Kew.

There is, however, a record at the Royal Botanic Gardens, Peradeniya, of introduction of oil palms to Ceylon as early as 1850, and Mr. Murton on his appointment as Superintendent of the Singapore Botanic Gardens in 1875, visited Ceylon on his way out. Seed may have been obtained both from Kew and from Ceylon. Further supplies of seed or seedlings were received in Singapore, from Kew, in 1886 and 1887. Subsequently, from Singapore, seed was variously distributed largely for ornamental palm purposes.

With relation to the low-growing ("dumpy") palms now being grown for commercial development at the Federal Experiment Station, Serdang, from an Elmina Estate parent, it is of interest to note that there is a record of a low-growing, heavy fruiting, 10 years old palm at the Botanic Gardens, Singapore in 1907.

In 1876, seed was sent from the Royal Botanic Gardens, Kew, to the island of Daat near Labuan, but 10 years later the palms were removed and coconuts planted.

First Experimental Oil Palms in Malaya.

The first seed planted by the Malayan Government for experiment purposes was at the old Experimental Plantation, Batu Tiga, Selangor. The land for this experimental plantation was acquired in September, 1902, and was opened up in October to December of that year during very wet weather which delayed clearing; there is no actual record of the planting of oil palms, but in the Annual Report of the Director of Agriculture for 1908, 35 six-years old palms are mentioned as growing at Batu Tiga; presumably they must have been sown or planted early in 1903. There is no available record of the origin of this seed. The Department of Agriculture was formed in 1905, and more seed, also of unrecorded origin but apparently of "Deli" type, was sown in the Public Gardens, Kuala Lumpur, in the same year. There is a brief note in the Agricultural Bulletin, F.M.S., Vol. 1 of 1912, that oil palm seed was then available in fairly large quantities.

Seed from Nigeria of hard-shelled and thin-shelled varieties was also planted in the Public Gardens by the Department of Agriculture in 1908.

The Batu Tiga Experimental Plantation (eventually abandoned during 1922) was, by 1910, proving unsatisfactory for further development on account of the prevalence of malaria, and the experimental work of the Malayan Department of Agriculture was transferred from there to the Experimental Plantations, Kuala Lumpur, where 15 acres of oil palms were planted in 1912 with seedlings of selected palms in the Public Gardens. It is recorded by Milsum, 1921, that these palms were of the "Deli" type but, as stated above, there is no record of their precise origin. Three varieties from Nigeria—microsperma (?), a normal "dura" type,

and a "mantle" fruited—were also planted in the Experimental Plantations, Kuala Lumpur, in 1914.

Then, in 1922, selected seeds and seedlings from the Experimental Plantations, Kuala Lumpur, were planted at the new Experimental Plantation, Serdang, Selangor, where individual palm selection was continued.

The oil palm populations established for experimental purposes at Serdang also included collections of different West African varieties imported direct or via London and planted between 1925 and 1928; these varieties included thin-shelled and shell-less fruited palms which are now being used for extension of the genetic range of the "Deli" type in experimental breeding at this Experiment Station.

Commercial Oil Palm in Malaya.

The earliest commercial development, however, apparently was independent of the Department of Agriculture, for in 1911, M. Henri Fauconnier purchased a bag of seeds from St. Cyr Estate in Sumatra, and with them planted part of the arrow-shaped avenue of palms to the bungalow at Rantau Panjang Rubber Estate near Batang Berjuntai, Kuala Selangor. M. Fauconnier chose these seeds himself from the best palms in the entrance avenue of St. Cyr Estate.

Some time later, about 1912, M. Fauconnier obtained more seeds from Tandjong Morawa Kiri Tobacco Estate near Deli, where M. Adrian Hallet had selected three of the best palms amongst a considerable number under observation. Palms grown from these seeds were also planted at the Rantau Panjang Estate entrance. The Rantau Panjang bungalow was known as "La Maison des Palmes."

Tennamaram Estate, near by, was being opened up for coffee planting, and M. Parant, a brother-in-law of M. Fauconnier, commenced to build the estate bungalow at the end of 1913. The garden was planted with oil palms of the "best jungle species" by which must be inferred that some oil palm seed was obtained from West Africa.

However, after an unsuccessful coffee experiment, oil palm seed was obtained from the Rantau Panjang avenue, and the first seedlings planted in 1917 in Tennamaram Estate became the first commercial oil palm plantation in Malaya.

An interesting record has just been obtained by Messrs. Cumberbatch & Co., Ltd. from M. Henri Fauconnier himself, who originally planted up Tennamaram Estate, and who writes as follows:—

> "Tennamaram is the first Estate in Malaya where Oil Palms were planted on a large scale.
>
> "I selected the seeds from Oil Palms planted on an avenue to the bungalow of Tandjong Morawa Kiri Tobacco Estate on the occasion of a visit to Sumatra. Several Estates in Sumatra possessed such avenues (purely decorative), but the palms on Tandjong Morawa Kiri were certainly the best as regards size of bunches, thickness of pulp, etc.

"The seed was set in nurseries on Rantau Panjang Estate, Kuala Selangor (a property of Plantations Fauconnier & Posth) in 1911, and seedlings from the said nurseries utilised to plant up Tennamaram Estate."

The second commercial oil palm plantation, also in the Kuala Selangor district, was developed at Elmina Estate. The estate was first opened up in about 1919, and the first 40 acres planted in 1920. A total of 570 acres were planted in 1920 to 1922, and a total of 1,010 acres by the end of 1923.

Elmina Estate was, for a while, the property of an ex-servicemen's syndicate, but whether they were the original owners or not seems uncertain. There is the possibility that the original owners may have been a French syndicate. The property eventually passed to the ownership of the Selangor Oil Palms Co., Ltd. about 1924. An early report of the company states that "the palms are of the variety dura, commonly known as the "Deli" type of original stock via Buitenzorg."

An interesting record has very recently been obtained in a letter from Mr. L. H. D. Robb, the first manager of Elmina Estate, 1919 to 1922, to Messrs. Cumberbatch & Co., Ltd. in Kuala Lumpur. Mr. Robb states that "the seed originally used was supplied, by one of the syndicate, from the oil palm plantation at Batang Berjuntai, now belonging to Socfin, situated at the entrance to what is, I believe, Sungei Tinggi Estate." This entrance to Sungei Tinggi Estate is, primarily, the entrance to Rantau Panjang Estate.

Mr. Robb, in his letter, suggests that the original seed for Rantau Panjang came from the Elmina region of the Gold Coast of West Africa, in which he is wrong by other records, but he probably has in mind the palms planted in the old Tennamaram Estate bungalow garden. He also refers to the failure to germinate of the original seed sown on Elmina Estate, and it is possible that this was the main bulk of the consignment of the seed sown in the old Tennamaram garden. It is natural that most of the seed, after a long journey by sea from West Africa, would fail to germinate.

There is further record of purchase for Elmina Estate in 1924 of 50,000 seeds from Sumatra, but the original areas on Elmina Estate, planted with Rantau Panjang seed in 1920 to 1921, include the field in which the selection work by the Department of Agriculture was carried out in 1929 to 1940.

Subsequent Selection and Breeding by the Department of Agriculture.

In 1929, the Botanical Division of the Department of Agriculture, in addition to the work at Serdang, initiated further oil palm selection in a 12 acres block (600 palms) of 1921 planting on this Estate. Staff limitations would not permit of a larger population of palms to be included in this study, but individual palm records were kept in considerable detail.

After eight years accumulation of records of yields of fruit bunches, and physical analysis of bunch and fruit characters of individual palms in this 12 acres field, selection of palms was made, consideration being given to apparent variations in soil fertility and to height of palms.

"Selfs" and "crosses" of these "Deli" palms, including the low-growing original "dumpy" parent, were planted at the Federal Experiment Station, Serdang, in 1937, 1939 and 1940 and constitute a major portion of the foundation stock of the Department of Agriculture's present breeding programme.

Conclusion.

It has been of interest to trace the history of "Deli" palms in Indonesia and Malaya, and in particular to establish the line of relationship between the "dumpy" palms and the original four Buitenzorg palms, via Deli, Sumatra.

Since this article was sent to the printers, the writer has been in Java, and has had the pleasure of a visit to the Botanic Gardens at Bogor at the invitation of the Government of Indonesia, and under the guidance of Mr. C.L.L.H. van Woerden, Curator of the Gardens.

It is of interest to record that, while two of the original four palms planted in 1848 were cut out some years ago to make way for an approach road to a bridge, two are still standing, now grown to heights of over 70 ft. but in good health.

The writer also visited the Central Agricultural Research Station at Bogor (formerly the Economic Gardens), and saw that, of the acre of palms planted in 1878, 13 palms are also extant and healthy.

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Appendix A.

ACREAGE UNDER OIL PALMS, 1917 to 1951.

State	1917	1918	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	1930	1931
Perak	—	—	—	—	—	—	—	200	200	703	2,144	4,941	9,316	17,179	17,362
Selangor	215	428	657	1,308	1,906	2,349	4,240	5,815	7,131	8,961	10,396	11,282	12,294	12,939	13,080
Negri Sembilan	—	—	—	—	—	—	—	—	—	504	504	504	604	774	940
Pahang	—	—	—	—	—	—	—	—	—	—	—	592	687	788	788
Johore	—	—	—	—	—	—	—	—	1,043	2,314	4,926	6,435	8,728	19,028	24,403
Kelantan	—	—	—	—	—	—	—	—	—	—	—	—	—	—	600
Malaya Total	215	428	657	1,308	1,906	2,349	4,240	6,015	8,374	12,482	17,970	23,754	31,629	50,708	57,173

State	1932	1933	1934	1935	1936	1937	1938	1939	1940	1947	1948	1949	1950	1951
Perak	17,372	17,426	17,405	17,405	17,405	17,542	18,038	18,461	18,850	20,037	20,798	22,120	23,086	23,204
Selangor	13,315	13,505	13,592	13,600	13,790	14,197	14,570	15,298	15,757	15,796	16,963	17,585	20,073	20,922
Negri Sembilan	1,173	1,199	1,422	1,273	1,903	2,084	2,494	2,584	2,787	2,688	2,746	2,841	3,041	3,058
Pahang	788	788	797	797	1,008	1,457	1,554	2,340	2,712	1,596	3,103	5,830	5,677	5,989
Johore	27,777	30,028	30,689	30,649	30,381	32,905	34,946	36,591	37,075	37,514	39,160	41,078	43,052	42,990
Kelantan	600	700	700	700	740	740	541	551	552	550	550	550	550	485
Province Wellesley	—	—	—	—	—	—	—	—	—	—	—	503	503	729
Malaya Total	61,025	63,646	64,605	64,424	65,227	68,925	72,143	75,825	77,733	78,181	83,320	90,507	95,982	97,377

THE "DUMPY" OIL PALM

BY

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In 1929, the Botanical Division of the Department of Agriculture, in addition to doing work on oil palms at the Federal Experiment Station, Serdang, initiated selection in a 12 acre block (600 palms) on Elmina Estate, Kepong,—the second commercial plantation to be established in Malaya (in 1920) with "Deli" seed. Staff limitations would not permit of a larger population of palms to be included in this study, but individual palm records were kept in considerable detail.

These records of the factors which make up the yield of palm oil included the number of fruit bunches, the weight of bunch, the proportion of good fruits in the bunch, the percentage of oily pericarp on the fruits, and the percentage of oil in the pericarp. This latter character remains fairly constant in fully ripe fruits, but requires to be checked.

Other factors of importance which were considered were height of palm, pollen production, and relative soil fertility and other positional advantages of individual palms.

After eight years accumulation of records of yields of fruit bunches, and physical analyses of bunch and fruit characters of individual palms in this 12 acre field, selection of palms was made, consideration being given to apparent variations in soil fertility. The palms under particular observation included two which were notable for large girth and slow height increase.

These two low-growing, thick-stemmed palms were vigorous palms with large crowns of leaves and high rates of leaf production. They had unusually low angles of phyllotaxy, accompanying high rate of leaf and fruit-bunch production with slow height increase. The better of these two palms, E.206, was eventually included in the final list of selections.

The dimensions of this palm and, for comparison, of normal palms are as follows:—

Table I.

	Girth at 4 ft.	Height at 15 yrs.	Height at 21 yrs. (1941)
E.206	113 ins.	11 ft.	13.7 ft.
Normal	89 ins.	17 ft.	22.5 ft.

Fruit bunches of the "dumpy" palm, E.206, were large, but the average annual crop of fruit bunches, at 363 lbs., was not up to full selection standards. Percentage of clean fruit was good, although the bunches were somewhat less-regularly formed than most others; percentage pericarp at 63 was above average but not up to the 66 set as a selection standard.

In all, the fruiting characters just failed to secure selection of the palm on first consideration. Moreover, the palm was growing at the sharp junction of two drainage ditches, and was considered to be unusually favourably sited.

Nevertheless, the low growing habit continued to be a matter of considerable interest and speculation with regard to its genetic synthesis and its possible economic value, because the ease with which bunches were harvested was fully appreciated by the writer.

Subsequently, an examination of root development of this palm, E.206, showed that, far from the palm being favourably sited in its close position to two wet ditches, root growth was considerably warped and probably much restricted in effective superficial feeding area, so that fruiting characters might well be adversely affected.

Much time is spent in harvesting tall palms, and it is estimated, now, that harvesting 10 ft. palms costs 3 cents per bunch, but that harvesting 25 to 30 ft. palms costs 12 cents per bunch. The oil palm industry, prior to 1937, was, however, still in its relative infancy, and the difficulties and high costs of harvesting tall palms did not intrude unduly amongst estate problems. Just about that time, however, several palms, both in the selection field and elsewhere, started shedding frond bases by which the palms had been climbed, and ladders became more and more essential to obviate climbing risks at harvesting. Costs of harvesting were thus increasing and were being more closely considered.

These increasing harvesting difficulties confirmed that the "dumpy" character of E.206 should not be neglected, and this palm was included in the breeding programme. It was decided that the manner of inheritance of the "dumpy" character should be studied.

In 1937 and 1939, a number of 1935 to 1937 "selfed" progenies of selected normal, tall palms were planted in replicated progeny rows in Field 4 at the Federal Experiment Station, Serdang, and one small bunch of "selfed" seed of the "dumpy" palm E.126 provided 22 seedlings for two rows.

During 1938, several more "dumpy" palm inflorescences were self-pollinated; others were cross-pollinated by and on the two selected normal, tall palms with the best fruit characters, in order to provide progeny with possible useful combinations of low growth and optimum fruit characters, and for possible back-crossing to "dumpy" palms.

The resulting seeds were sown at the Federal Experiment Station, Serdang, in 1938 and 1939. However, in April, 1940, there was still great difficulty over suitable land at Serdang, and for the 400 seedling "selfed" progeny of E.206, and the equally large progenies of "crosses" of E.206

with the two selected tall palms, only 1¼ acres of Field 3A was available; 40 to 43 of each of these progenies were planted in consecutive small blocks. The war years intervened before further observations could be made; unfortunately, in the interval, the original mother palms on Elmina Estate were cut out to make room for cultivation of urgently required annual food crops.

In 1945 and 1946, the oil palm experiment fields at Serdang were cleaned and recultivated, and although the palms were still very young, it was soon appreciated that the palms of the "dumpy" "selfed" family appeared to be remarkably uniform and true to type in "dumpiness" compared with the other palms.

The comparative "dumpy" habit was unmistakable, and its genetic basis was a matter of controversy, as was the question whether the growth characters of the "dumpy" x tall cross-pollinated palms were intermediate or of a dominant tallness.

Records of yields of fruit bunches of individual palms were commenced in July, 1946, and analysis of fruit characters in 1947. The palms had apparently achieved recovery early in 1948, and at the end of that year provisional selections were made with which to continue breeding experiments at the earliest possible date. Some revision of selection has been made as records have accumulated.

The F 1 generation "dumpy" palms are now between eleven and twelve years old, and bunches are still being harvested from the ground. Normal, tall palms, planted just a year earlier, have required ladders for harvesting for the last four to five years.

The height and girth measurements of the original "dumpy" parent are quoted above. The measurements of these characters for its "selfed" progeny at approximately 10 and 12 years old are given in Table II, comparing them with corresponding measurements for the normal tall palms of the "selfed" progenies of the selected palms E268 and E152 approximately 6 months older. Measurements of palms in cross-bred progenies of the "dumpy" parent E206 with both of the above tall palms are included for further comparisons and which are commented upon later in this article.

Table II.

Mean Heights and Girths of Oil Palms, 1950 & 1952.

(Based on 40 palms in each progeny).

Progeny.		Year planted.	Girth in inches.		Height in inches. (To harvesting point).	
			At 1 foot 1950	At 4 feet 1952	1950	1952
"Tall."	E268 "selfed"	1939	110.8	93.1	148.7	186.8
"Cross."	E206 x E268	1940	122.5	98.2	126.2	160.3
"Dumpy."	E206 "selfed"	1940	124.9	107.2	94.4	114.5
"Cross."	E152 x E206	1940	106.1	87.0	127.8	161.6
"Tall."	E152 "selfed"	1939	91.7	80.9	134.4	164.1

There is now no doubt about the "dumpy" characters of the "selfed" progeny of palm E.206, nor of the high degree of their uniformity in this respect. It may be expected that the F2 progeny will be the same, and that all legitimate "dumpy" oil palms will have the great economic advantage of slow rate of height increase, accompanied by vigour of growth and high rate of inflorescence and fruit production, providing easier and cheaper harvesting conditions compared with the normal oil palm; furthermore, as height and attendant harvesting difficulties are major factors influencing the economic life of the crop, it is likely that this economic life will be considerably extended by the slow height increase.

The "dumpy" palms in Field 3A have not been planted in replicated progeny trials with the others in Field 4, so that yields cannot be statistically compared, but the two fields are immediately adjoining and general comparisons can be made. Selection and "selfing" of palms were made for genetic study of several characters and not all the palms used were primary selections for superiority in production of pericarp and oil.

The annual and mean yields per palm of the various progenies in Fields 4 and 3A are given in Table III. From these figures, it is evident that the "dumpy" family is amongst the highest yielding. Assuming an extraction rate of 15 per cent. oil from bunch, the "dumpies" have yielded at the rate of 17.75 cwts. of oil per acre over the period 1948 to 1951.

Table III.

Mean Yield per Palm of Fruit Bunches of Various Progenies for Comparison with that of E206 Selfed.

Progeny.	Year planted	No. of palms	Mean yield 1946	Mean yield 1947	Mean yield 1948	Mean yield 1949	Mean yield 1950	Mean yield 1951	Mean yield 1947-1951
			lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
"TALLS"									
E211 "selfed" Field 4	1937	51	162	229	261	197	195	213	219
E200 „	1937	52	139	176	156	156	147	122	151
E268 „	1939	57	141	220	286	197	207	219	226
E216 „	1939	57	132	204	229	211	155	208	201
E207 „	1939	62	89	136	178	137	136	145	146
E152 „	1939	51	91	129	178	135	130	163	147
"DUMPIES"									
* E206 „	1939	22	79	117	205	133	86	107	150
E206 "selfed" Field 3a	1940	41	95	159	279	257	230	229	231
"CROSSES"									
E206 x E268 Fld. 3a	1940	44	135	187	309	179	145	208	206
E152 x E206 Fld. 3a	1940	42	113	166	252	187	224	261	218

* Shaded by tall palms.

This yield was obtained in rather poor, hill soil, without the aid of heavy dressings of fertilisers, and there is evidence of approximately 100 per cent. increase in yields of some of these progenies in better conditions elsewhere.

Effects of Shade.

The 22 "dumpy" palms in Field 4, planted between rows of the tall palms, are, with the exception of the palms at the end of the rows, clearly very much affected in yield by the overshading of the taller palms. This is an important observation.

Bunch and Fruit Characters.

Three bunch and fruit characters have been studied in particular—mean bunch weight, clean fruit on bunch, and pericarp on fruit (see Table IV). The figures show that the "dumpy" palms have a relatively large bunch, the average bunch weight reaching 39 lbs. in 1950. The pericarp on fruit figure of 64.5 per cent. is well above average, even for "Deli" type palms. The oil in the pericarp of the "dumpy" palms has been checked and is well up to the "Deli" palm standards of 77 to 81 per cent. of the dry pericarp.

Table IV.

Average Bunch Characters of Various Progenies, for Comparison with those of E206 "selfed".

	Mean Bunch Weight (lbs.)						Clean Fruit on Bunch.	Pericarp on Fruit.
	1946	1947	1948	1949	1950	1951		
							per cent.	per cent.
"TALLS"								
E211	22	25	33	35	33	35	61.7	60.5
E200	28	31	43	46	40	43	62.8	61.8
E268	17	21	28	31	35	36	58.0	64.2
E216	19	22	27	28	30	31	58.4	63.4
E207	19	25	30	33	37	37	63.3	61.1
E152	17	21	27	27	30	33	59.6	67.5
"DUMPIES"								
E206	—	27	35	37	39	37	54.2	64.5
"CROSSES"								
Fld. 3a								
E206 x 268	—	27	36	34	39	44	55.3	64.7
E152 x 206	—	22	31	35	39	42	67.8	62.3

The clean fruit on bunch figure of 54.2 per cent. is, however, definitely low. This is due to an unusually large number of small under-

"Dumpy" oil palm at 12 years old.

"Dump" (E.206) and tall (E.120) oil palms at 12½ years old.

developed parthenocarpic fruits which nevertheless contain some oil. It is feared, however, that the oil extraction rate of fruit bunches of these "selfed" "dumpy" palms must at present be slightly lower than for ordinary "Deli" palms, but further selection and breeding should evidently affect improvement, as has already been indicated in the experiments in progress.

Dumpy x Tall Progenies.

(E.152 x E.206) and (E.206 x E.268).

There are three points of particular interest about the "dumpy" x tall progenies.

As will be seen from Table II, these "crossed" palms are clearly intermediate in girth between the short thick-set "dumpies" (E.206 selfed) and the corresponding "selfed" progenies of the other parents (E.268 and E.152). This clearly suggests that the "dumpy" girth character is an expression of quantitative genetic factors, and is not a simple recessive, which is of particular interest as the original "dumpy" parent palm, E.206, has given a family, which although segregating fairly widely in yield and fruit characters, is apparently homozygous for this character "dumpiness."

As regards height, however, especially taking the six months difference in age into account, there is no certain evidence of any intermediate expression of this character. The successive 1950 and 1952 measurements suggest that this may be due to a relatively greater rate of growth of the "crossed" progeny compared with the "selfed" progeny, or to some difference in soil fertility between Fields 3A and 4, but no deductions can be made without much further observation.

The third point of interest is the extraordinary high clean-fruit-on-bunch figure of 67.8 per cent. for the E.152 x E.206 progeny (see Table IV). As has been stated, the "dumpy" palms give a figure of 54.2 per cent. only, compared with a field average of about 60 per cent. Not all the palms in this "selfed" "dumpy" family have such a relatively low percentage of good fruits per bunch, and it is apparent that it should not be difficult to breed away from this fault. It is hoped too, to use the outstanding quality of the E.152 x E.206 progeny to improve the "dumpies" in this character.

Selection in the F1 Progeny.

There are only 63 "dumpy" palms in the F1 generation, and of these 22 are in Field 4. In Field 3A, 12 palms are in outside rows, 11 next to taller palms and partially shaded, leaving only 18 palms in the centre of the plot. The palms in Field 4 are nearly all overshaded by tall palms, and are yielding badly. These facts, together with a considerable fertility gradient, have made the selection of palms exceptionally difficult. The policy has therefore been to keep the selection on as wide a basis as possible to ensure that good palms which are unfavourably situated are not excluded.

In making the selections, the various bunch characters have been considered as well as yield. The data relating to selected palms are given in Tables V and VI. In general, the selected palms are considerably better than the progeny mean in all essential characters although a few have been selected for outstanding merit in one character only.

Selection in the two "dumpy" x tall progenies was easier as these progenies are in single, compact blocks, and are not affected by overshading.

Table V.

Yield of Selected Dumpy Palms (E206 "selfed").

(Fruit Bunches in lbs.)

Field 3a.

1940	1946	1947	1948	1949	1950	1951	Total 1947-51	
1.1	150	74	355	397	395	364	1,585	(Corner palm)
1.7	62	258	440	285	141	108	1,232	
1.9	126	113	322	225	243	192	1,095	
2.3	63	129	355	372	421	205	1,482	
2.4	153	274	335	269	320	250	1,448	
3.5	129	94	357	370	212	202	1,235	
3.8	72	285	293	124	175	201	1,078	
Progeny Mean	95	159	279	257	230	229		

Field 4.

1939	1946	1947	1948	1949	1950	1951	Total 1947-51
52.6	68	144	310	164	167	141	926
55.8	85	232	353	52	47	122	806
Progeny Mean	79	117	205	133	86	107	

Breeding.

Legitimate "Dumpy" Progenies.

The breeding programme was not originally planned in great detail. Selected "dumpy" palms were "selfed" or "crossed" as the opportunity occurred. Most of the desirable combinations were achieved in this way and a maximum amount of legitimate seed was produced in the minimum time. Only a few palms were "selfed" and a supplementary programme to "self" the remainder is under consideration.

Table VI.

Bunch Characters of Selected Dumpy Palms (E.206 "selfed")

(Mean weight per fruit bunch, in lbs.)

Field 3a.

1940	1946	1947	1948	1949	1950	1951	Clean Fruit on Bunch.	Pericarp on Fruit
							per cent.	per cent.
1.1	25	19	39	33	33	24	50.2	71.5
1.7	31	29	49	36	47	54	56.2	67.7
1.9	25	28	36	32	61	38	70.7	61.8
2.3	21	43	50	53	52	51	58.6	67.8
2.4	19	26	31	41	80	35	54.3	61.7
3.5	22	24	40	41	42	33	53.8	67.9
3.8	12	29	29	41	58	25	60.1	64.3
Progeny Mean	—	27	35	37	39	37	54.2	64.5

Field 4.

1939	1946	1947	1948	1949	1950	1951		
52.6	11	21	28	23	28	35	50.4	65.3
55.8	17	19	32	26	47	24	64.4	60.5
Progeny Mean	—	21	30	31	31	28	57.9	60.6

The present position is that two principal F2 generation nurseries have been established, which contain about 60 to 100 seedlings from each of a number of different progenies. Two progeny trials of about 50 and 30 acres each will be laid down.

Further seedlings from the same F2 progenies have been distributed to five estates. These estates have agreed to plant each progeny in a single observation plot (of about 5 to 8 acres each) on land chosen for its uniformity.

These plots should be of great value for future selection, especially after the results from the two progeny trials have been obtained.

It is unfortunate that all this material is the F2 progeny of a single palm (E.206). On general principles, inbreeding of a crop which is normally out-pollinated may be dangerous. The fact remains, however, that no other palm with the distinct habit of the "dumpy" palm, E.206, has been found.

With the co-operation of the oil palm planting industry, a total of 23,000 legitimate "dumpy" seedlings have now been distributed. If these trials and observation plots confirm the early promise of the "dumpy"

palms, a population of over 20,000 palms should provide useful material for future selection and breeding. Pedigree seed has also been sent, on request, to research stations in West Africa and South America in exchange for other material.

"Back-crossed" Progenies.

The progeny of the cross E.152 x E.206 have an exceptionally good percentage of clean fruit on bunch. True back-crossing of the best palms onto E.206 is not possible as that original parent palm has been destroyed. Therefore selected palms in the original family E.152 x E.206 have been crossed with selected F1 generation "dumpy" palms of the "selfed" E.206 progeny.

It is hoped by this means to transfer the good clean-fruit-on-bunch character into palms of the "dumpy" habit. An observation plot of 980 seedling palms of this pedigree (E.152 x E.206) x (E.206 "selfed") has recently been planted in a field on an estate.

A few seedlings of the pedigree (E.206 x E.268) x (E.206 "selfed") are in the nursery at Serdang and will soon be ready for the field. As E.268 "selfed" has proved to be a high yielding progeny in a replicated trial, it is hoped that these two different types of "three-quarter" bred "dumpy" palms may prove of value in reducing the dangers of inbreeding.

"Tenera Dumpies."

Recent breeding experiments in the Belgian Congo and in Sumatra have shown that the cross between thick-shelled "dura" palms and shell-less "pisifera" has resulted in thin-shelled "tenera" progenies giving extraction rates of over 20 per cent.

Accordingly, pollen from selected "pisifera" palms at the Federal Experiment Station, Serdang, has been crossed onto selected "dumpy" palms. Further "pisifera" pollen has been imported from selected palms in Nigeria and used in similar manner. A few small progenies of the "dumpy" x "pisifera" type will be planted to investigate the possibilities of producing high yielding "dumpy-tenera" palms. At least two more generations of breeding will be required to produce a true "dumpy-tenera" palm and the project is therefore a long term one.

The production of "dumpy-tenera" palms would be a further great step forward provided yield were not sacrificed.

Summary.

The history of the original "Dumpy Deli" oil palm and the family of "selfed" progeny is described, and morphological comparisons with normal tall "Deli" palms are made. The genetic synthesis of the "dumpy" habit is briefly discussed. The "dumpy" habit of *Elaeis guineensis* is apparently new in the oil palm industry, both in Malaya and in other parts of the world, and there is a rapidly growing demand for pedigree seed of palms of this type.

The large girth of these "dumpy" palms is accompanied by slow height increase and a high rate of fruit-bunch production, which allows the possibility of high yields to be allied to more convenient harvesting and relatively long economic life.

A defect in the present small "selfed" family of "dumpy" palms is the relatively low (54.2) percentage of good fruits in a bunch, with a corresponding high percentage of infertile fruits; but this is not common to all of these palms, and improvement of this character is likely to be attained readily in an experimental breeding programme.

Reference is also made to further breeding work, by which it is hoped to incorporate the high percentage pericarp of the "tenera" type fruits with the "dumpy" palm habit.

Acknowledgements.

I am indebted to Mr. E. A. Rosenquist, Botanist, stationed at the Federal Experiment Station, Serdang, who is now in immediate charge of oil palm breeding work, for his interest in and supply of experiment data for the various tables and for other information included in this paper.

I would like to thank, also, several successive Agricultural Officers in charge of the Federal Experiment Station, Serdang, for their interest in and care of the experiment fields, and the Senior Chemist of this Department for analyses of oil contents of pericarp.

I would like also to express here my great appreciation of the most hospitable co-operation of the late Mr. David McCrow, on Elmina Estate, from 1929 to the date of his retirement in 1948. Without Mr. McCrow's interested co-operation this oil palm selection work on Elmina Estate would not have been continued, and the "dumpy" palms might not now be in existence. I am sensible, too, of a personal debt to him and his wife that I was able to call myself their friend.

"GELAM" SOILS

A Study of Their Sulphur Content

BY

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Introduction.

The *gĕlam* soils of Malaya take their name from the *gĕlam* tree (*Melaleuca leucadendron*) which is a moderate-sized Myrtaceous tree. It is characterised by a bark resembling layers of paper, and an essential oil (Cajput oil) which may be distilled from the leaves (2). The trees occur widely in the low-lying, swampy lands of the river and coastal alluvium and on the poor sandy soils, swampy and dry, on both the east and west coasts. It sometimes occupies sandy areas within the limits of mangrove swamps and may be regarded as a species especially tolerant of very adverse soil conditions, acid, saline, waterlogged or arid. With its thick, papery bark it is resistant to fire, and pure stands are probably sometimes due to this ability to survive fires in which other species perish.

The peasantry are strongly prejudiced against *gĕlam* soils for padi planting, for experience indicates that padi often fails on these soils and they conclude that the *gĕlam* is responsible for something injurious in the soil. An idea that has been put forward is that the roots of *gĕlam* secrete a toxic substance which is injurious to most other species and that the *gĕlam* water of the streams flowing out of *gĕlam* forest is harmful to padi areas irrigated by it. Stagnant water from the extensive *gĕlam* complexes exposed to recurrent fires shows a noxious reaction and contains iron and aluminium compounds derived mainly from the thick layers of ash (11).

The situation is complicated by the experience of cultivators that on some *gĕlam* areas it has been possible, after clearing, to grow padi fairly well for a year or two before deterioration supervenes. It is also reported that in certain areas in Kelantan (Kampong Haji Saman) rapid deterioration in crops took place about two or three years after the areas had been opened up. Padi planting has been continued at one end of this area, where the land is slightly higher than the rest of the area and drainage somewhat better, but nurseries are sown in dry land and seedlings are only transplanted into the *gĕlam* soil four to five weeks after the land has been flooded by adequate rain water In this portion of the area crops have gradually improved over 20 years.

This need for delay in transplanting of rice in old *gĕlam* land following very dry weather has occasionally also occurred in parts of Malacca.

In explaining the harmful nature of certain *gĕlam* soils it may be assumed that either there are large amounts of particularly harmful

substances or that *gĕlam* roots secrete some form of toxin which renders the soil infertile. It is frequently found that at depths of 6 to 24 ins. below the surface, *gĕlam* soils smell distinctly of hydrogen sulphide. Van Wyk (11) reports that in Borneo a large amount of *gĕlam* debris has been found to be strongly acid and to contain sulphates.

From the foregoing considerations it was decided to investigate the occurrence of sulphur in *gĕlam* and other swamp soils, since this might be a factor in their toxicity. Investigations have also been carried out into the amount of sulphur actually occurring in *gĕlam* wood and in timber of other species growing under swamp conditions.

Sources and Forms of Sulphur in Soils.

When considering sulphur, a point of importance is the source of the element in the soil. Under reducing conditions iron sulphide is formed when water carrying iron compounds comes into contact with solutions with calcium and magnesium sulphate, as for example in sea water. Most rocks also contain small amounts of sulphur and, on weathering, this is probably carried away by water and retained in insoluble form in swamp areas. In swampy conditions, sulphur will be preserved in the soil either in the organic form as sulphides or it will be taken up by plants and stored in the organic form. The sulphur in complex organic combination probably undergoes a cycle of changes analogous to those for nitrogen. Bacteria, causing decomposition, will liberate sulphur as sulphuretted hydrogen from organic combination. If conditions are favourable, other organisms could oxidise this to free sulphur and finally to sulphuric acid.

Sulphur, in addition to occurring in organic combination, forms several naturally occurring compounds with iron, for example pyrites and marcasite (13). Marcasite, as well as other minerals of the same composition, can be produced in nature by the reduction of ferrous sulphate by organic matter, and is often found in peat, chalk and in clay containing such organic matter.

Mechanism of Sulphur Oxidation.

As permanent reducing conditions exist in swamps, it is important to consider what happens when the soil is drained and exposed to oxidation. It is probable that the oxidation of sulphur compounds can go on, both as a biological and as a chemical process (13). In the former, various kinds of sulphur bacteria are instrumental, while in the latter the oxidation takes place in a purely chemical way without the interference of organisms. The relative importance of the biological and chemical reactions may vary from soil to soil, essentially depending on the occurrence of suitable sulphur bacteria.

The hydrogen sulphide which is formed under reducing conditions in the soil can react with iron compounds of the nature of oxides and form iron pyrite FeS_2 (11). If this type of soil, in which FeS_2 has been formed under anaerobic conditions, is exposed to the air after drainage, the oxygen from the air will oxidise the sulphides. Finally, the

FeS_2 is almost entirely converted into ferrous sulphate and sulphuric acid according to the equation:

$$2FeS_2 + 7O_2 + 2H_2O = 2FeSO_4 + 2H_2SO_4$$

If the sulphuric acid is not neutralised by the lime in the soil, as will frequently happen in Malayan soils, then further oxidation to ferric sulphate can take place:

$$2\,FeSO_4 + 2H_2SO_4 + [O] = Fe_2(SO_4)_3 + H_2SO_4 + H_2O$$

Ferric sulphate is a whitish-yellow compound slowly soluble in water. Substances of this nature are found on the bare surface of dry bunds in certain of our alluvial soils.

Little is known, however, about the mechanism of the air oxidation of sulphur and sulphur compounds naturally occurring in soils. The rate of air oxidation is likely to be very much dependent on the solubility and the specific surface of the sulphide, the rate decreasing with decreasing solubility and specific surface. There is a great difference between the rate of oxidation of sulphide to sulphur and that of sulphur to sulphate, as has been shown in experiments by Wiklander (13). The sulphuric acid formed by oxidation reacts to a greater or lesser extent with the mineral substances of the soil. This occurs partly as an ionic exchange, cations beings replaced by the H ions of the acid, and partly as a direct dissolution of the soil mineral constituents such as Fe, Al and Mg.

Wiklander (13) also found that sulphate was easily reduced by the organic matter in acid suspensions if kept on a steam bath under anaerobic conditions, and he also mentions the fact that an oxidised sulphurous soil is gradually reduced by bacteria and turns black if kept under water in a stoppered bottle. By sterilising the soil he was also able to show that the oxidation from sulphur to sulphates continued, thus demonstrating that it was a chemical oxidation and not caused by micro-organisms.

Investigations into Sulphur Contents of Soils of Other Countries.

A considerable amount of investigation has been carried out elsewhere, especially in the United States, Nyasaland and Sweden, into the sulphur content of soils. In the two former countries, the investigations have been mainly into the deficiency in soils, e.g. the "tea yellows" of Nyasaland. In some other areas, investigations into excess sulphur in the soils have been carried out. Kivinen (6 and 7) gives a description of the 'alum' soils of Finland which are distributed mainly in coastal areas and where the presence of sulphate is said to result from gypsum formations. The content of soluble salts in the top soil varies from 0.5 per cent. to 3.5 per cent. as aluminium, calcium and sodium sulphates and chlorides, but mostly sulphates. These areas are reported to be practically barren except for one or two species which are tolerant.

Ehrencron (4) discusses the toxic effects of sulphur on a padi *sawah* in Java. In this case the sulphur was being introduced artificially in the waste water from a soda ash factory. Results showed that the injury

was accompanied by high acidity, a high proportion of insoluble sulphur compounds and soluble sulphates. A toxic medium was formed from the free sulphur as a result of microbiological activity. The critical values were pH less than 3.5, insoluble sulphur compounds greater than 0.5 per cent. and soluble sulphates greater than 0.25 per cent. It was also found that fish culture in the water in this area was impossible.

Dougall (3), working on the reclamation of tidal flats in Sierra Leone, found that, in the absence of adequate leaching when sea water is excluded, sulphides are oxidised in the dry season and high acidity develops, preventing growth in the following wet season. A drainage system permitting adequate leaching is essential to remove harmful salts, excess rain water or seepage water and to prevent undue rise of ground water.

Wilshaw (14) discusses the development of acidity of coastal clays in Malaya and points out the very high acidity which develops when these soils are dried out; the soil contained 5 per cent. of sulphate after allowing the sample to dry for one month. The acidity ensuing from the oxidation of insoluble sulphur compounds consequent on opening up and draining an area was also noted by Griffith (5) and he points out that virgin *gĕlam* soils contained only small amounts of water soluble sulphates. *Gĕlam* land which has been freshly opened up, and also that which had been under cultivation for several years, contained considerable amounts of water soluble sulphates.

In the soils of certain estates on coastal clays which the writer has examined with in recent years, considerable amounts of water soluble sulphates have been found at no great depth from the surface in spite of the fact that drainage was reasonably good.

Scope of Present Investigation.

In the present investigation, the development of acidity and sulphate content on drying, the determination of the total sulphur content in certain soils, both *gĕlam* and non-*gĕlam*, and the sulphur content of wood, both *gĕlam* and other species growing on swamp soils, and finally small scale laboratory experiments on the amelioration of these conditions in soils have been examined.

Development of Sulphates on Drying.

It has been noted that water taken from the pits dug in soils containing a high percentage of sulphur does not contain much sulphate, and the inference from this is that little of the sulphur exists as sulphate under these conditions. In the laboratory, an experiment was set up in which 100 gms. of soil was leached daily with 200 ccs. distilled water and the sulphate content of the leachings determined. Table I gives the percentage of sulphur found each day in the leachings. The leaching was stopped from the 15th to the 24th day and the soils allowed to dry out before further leaching took place.

Table I.

Percentage of Sulphate Removed Daily by Leaching.

Ref. No.	Day 1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
R7402 S	0.548	0.868	0.232	0.143	0.061	0.061	0.036	0.031	0.076	0.066	0.068
R7625 Sc	0.132	0.195	0.136	0.122	0.077	0.082	0.077	0.067	0.077	0.066	0.072

Ref. No.	12th	13th	14th	15th	24th	25th	26th	27th	28th	29th	30th
R7402 S	0.066	0.044	0.056	0.088	0.091	0.073	0.038	0.022	0.021	0.013	0.010
R7625 Sc	0.076	0.072	0.070	0.072	0.146	0.108	0.066	0.056	0.036	0.030	0.020

Table I shows that even after a considerable amount of leaching there are still slight traces of sulphate. In similar leaching experiments, Wilshaw (14) analysed the leachings for anions and found that aluminium occurred in greatest amount.

The great increase in the water soluble salts which takes place on drying is strikingly demonstrated when the conductivity of a 1 : 5 suspension of the soil is measured before and after air-drying. Provided no chlorides are present it is possible to obtain an indication of sulphate content by measuring the conductivity before and after drying the samples. Results for measurement of the conductivity and water soluble sulphates before and after air-drying are given in Table II.

It will be seen from Table II that the increase in conductivity, when the soil has been air-dried, follows fairly closely the increase in sulphate content on drying. The measurement of conductivity provides a quick and reliable method of detecting the presence of abnormal salts in swamp soils.

Determination of Total Sulphur in Soils.

Two methods have been examined and both appear to give satisfactory results. The first method is that of the A.O.A.C. (1), in which the soil is fused with a mixture of sodium peroxide and sodium carbonate, the mixture extracted with water, made slightly acid with HCl and evaporated to dryness, heated to dehydrate the silica, then taken up in water and the sulphate precipitated as barium sulphate. The disadvantage of this method is the large amount of silica which is always present. An alternative method has been used in which the soil is heated with a solution of magnesium nitrate, evaporated to dryness, gently ignited and extracted with HCl, and sulphur determined by precipitation as barium sulphate. The sulphur in soil samples from a number of widely scattered areas has been determined on the air-dry samples, and the results are given in Table III.

Table II.

Change in Conductivity of Certain Soils on Drying.

Origin.	Depth.	Conductivity.		Water soluble sulphates.	
		Before drying.	After drying.	Before drying.	After drying.
	ins.	mhos x 10^6	mhos x 10^6	per cent.	per cent.
Pulau Gadong Padi Test Station, Malacca.	0— 6	77	217	0.036	0.041
	6—12	48	97	0.033	0.025
	12—18	80	297	0.073	0.041
	18—24	125	1080	0.041	0.424
	Below 24	151	1330	0.038	0.481
- do -	0— 6	60	221	0.015	0.029
	6—12	166	315	0.044	0.058
	12—18	243	1550	0.067	0.773
	Below 18	214	1150	0.056	0.453
- do -	0— 6	25	45	0.005	0.004
	6—12	30	44	0.021	0.025
	12—18	30	50	0.017	0.016
	18—24	73	1330	0.006	0.642
	24—36	110	1440	0.014	0.580
Duyong *gĕlam* area, Malacca.	0— 6	26	39	0.017	0.008
	6—18	21	30	0.006	0.004
	18—30	24	39	0.013	0.008
- do -	0— 6	26	40	0.021	0.072
	6—12	30	36	0.016	0.012

Consideration of Data in Table III.

Paya Besar is an area of the order of 3,000 acres situated near Kuantan, Pahang, which was opened up in the 1930s for padi planting. Padi has never grown with any success in the area, which is waterlogged throughout the year. Even alongside the drains the water table is only a few inches from the surface. The upper horizon consists of a brownish-grey, silty clay with a fairly firm texture; below this is a grey, silty material with the consistency of butter, and the colour of the material turns blue-black rapidly when exposed to the air. The smell of hydrogen sulphide is apparent as soon as one examines a pit. The most outstanding characteristic of the soils of this area is the presence of the soft layer underneath the surface. The values for loss on ignition show that the bottom layers generally contain more organic matter than the top. It would thus appear that there had been, at one time, a highly organic layer which became permeated with mud laid down at a later date. It was noted that the soils with horizons having the highest loss on ignition had also the highest sulphur content, i.e. there appeared to be a correllation between organic matter content and percentage of sulphur.

Table III.

Sulphur Content of Soil Profiles from Paya Besar, Pulau Gadong, Duyong and Tanjong Minyak.

Origin	Sample depth. ins.		Percentage of total sulphur.	Percentage of water soluble sulphate in air-dried sample.
Paya Besar, Pahang.	Profile I	0— 6	0.165	Nil
		6—12	0.149	Nil
		12—30	0.192	Nil
		30—40	1.015	0.202
	Profile II	0—14	0.139	Nil
		14—33	0.273	Nil
		33—39	1.604	0.230
	Profile III	0—12	0.361	Nil
		12—36	0.332	Nil
		36—40	2.666	0.880
	Profile IV	0— 8	0.183	Nil
		8—35	0.211	Nil
		35—40	1.560	0.255
		40—50	3.998	0.806
Pulau Gadong Padi Test Station, Malacca.	Profile I	0— 6	0.593	0.041
		6—12	0.378	0.025
		12—18	1.343	0.041
		18—24	1.435	0.424
		24—36	0.256	0.481
	Profile II	0—6	0.241	0.004
		6—12	1.610	0.025
		12—18	0.331	0.076
		18—24	1.452	0.642
		24—36	2.059	0.580
Duyong *gĕlam* area, Malacca.	Profile I	0— 6	0.258	0.021
		6—18	0.299	0.076
		18—30	0.263	0.021
	Profile II	0— 6	0.427	Nil
		6—18	0.633	0.021
		18—36	1.628	0.041
	Profile III	0— 6	0.281	Nil
		6—18	0.441	0.033
		18—36	0.546	0.132
	Profile IV	0— 6	0.299	Nil
		6—18	0.367	Nil
		18—36	0.369	Nil
*Tanjong Minyak *gĕlam* area, Malacca.	Profile I	0— 6	1.019	0.152
		6—18	6.553	2.045
		18—36	5.779	1.699
	Profile II	0— 6	0.997	0.074
		6—18	6.207	1.535
		18—36	6.807	1.572

* Within 6 miles of Duyong.

Examination of Table III shows that the sulphur content of the upper layers is comparatively low but that below 30 ins. these soils contain very considerable amounts of sulphur. The water soluble sulphate was determined in the samples after they had been air-dried for a fortnight, but it is obvious from the figures that oxidation to sulphate was far from complete. It is not known whether this area once carried a stand of *gĕlam*, but the results indicate the sulphur is probably a factor in its sterility.

Pulau Gadong Padi Test Station, Malacca, is an area which was once covered with *gĕlam*, and *gĕlam* still exists on the outskirts of the Station. A curious phenomenon in certain parts of the Station is the occurrence of patches, a few square yards in area, which are completely bare of vegetation. The surface of the soil cracks, and flakes of a hard, scale-like material, with a greenish-yellow colouring, form. This, when heated in a test tube, gives off a distinct smell of sulphur and the figures for analysis reveal a high percentage of sulphur. The soil itself is a fine, sandy silt, grey in colour, and the lower horizons turn blue-black on exposure to the air. The area is practically waterlogged, the water table being within 6 ins. of the surface. The soil from the deeper horizons has a strong smell of sulphide and even the samples of water from the pit smell strongly of H_2S. Like the Paya Besar soils, the lower horizons have a higher loss on ignition than the upper horizons. The results in Table III show that though these soils do not contain as high a percentage of sulphur in the lower layers as the Paya Besar soils, the horizon near the surface contains more. Pulau Gadong is an example of a former *gĕlam* area with a highly sulphurous and sterile soil.

Duyong is an area within 7 or 8 miles of Pulau Gadong where a pure stand of *gĕlam* exists. The area is waterlogged and carries a surface mat of decaying vegetation consisting of dead leaves, roots etc., and there is also a certain amount of ash mixed with the surface of the soil. The underlying soil is, in general, a white, silty clay with occasional sandy patches; a slight smell of sulphides can sometimes be detected, though it is often absent. The soil does not darken when exposed to the air. Table III reveals that the soil is very low in sulphur, hence the lack of smell and colour. We have, in this case, a pure stand of *gĕlam* on a soil only slightly sulphurous, yet it is within a short distance of Pulau Gadong.

Tanjong Minyak is also an area with a pure stand of *gĕlam*, and it is in the same general area as Pulau Gadong, being contiguous to it on the north. These soils had a very strong sulphurous smell and turned black on exposure. The analyses reveal the extremely high sulphur content of these soils. A large proportion of this sulphur must be held in relatively non-toxic forms, probably as iron sulphide, else the area would be practically barren of vegetation. The danger from this high percentage of sulphur would arise if the area were drained, thus allowing the development of large quantities of sulphuric acid and sulphates.

It would seem from the above results that sulphur occurs in a high concentration in the soils of certain areas while in others it is almost non-existent. This question of the variation in sulphur content will be returned to later when the opening up of these *gĕlam* areas is discussed.

Sulphur Content of Gĕlam and Other Species of Timber Growing in Swamps.

Since *gĕlam* appears to have a strong toleration for sulphurous soils, the amount of sulphur in the roots and stems of *gĕlam* and in the timber of some other species which grow in swamps has been determined. The roots of the *gĕlam* were obtained by pulling up the bush and cutting off the roots. These were air-dried in the laboratory and then brushed and washed to remove all traces of soil. The samples were ground in a mill before sub-sampling for analyses.

Table IV shows that, in general, the *gĕlam* from the Malacca area is higher in sulphur than that from Kedah and Kelantan, but it will be seen that the Duyong samples, where the soil is not particularly high in sulphur, contain more than the Tanjong Minyak samples where the soil is highly sulphurous. No sulphur determinations on the soils from Kedah, Kelantan and Trengganu have been carried out, but it is reported that growth of padi in the Batu Rakit area has been poor owing to unfavourable soil factors.

The Table also shows that the timber from the Klang area contains comparatively little sulphur. Although *gĕlam* appears to be tolerant of very high concentrations of sulphur in the soil it does not absorb particularly large quantities of it.

Amelioration of the Sulphur Toxicity in Soils.

Using the Neubauer technique, an attempt was made to grow padi on soil mixed with sand in small glass dishes. Some of the soils from Paya Besar, which had a very high content of sulphur, were used but the padi scarcely grew; any seedlings which did germinate grew to a height of about 1½ ins. then turned brown and died off. Potassium phosphate, in solution, was then added to the soils at a rate equivalent to 1 ton per acre of rock phosphate. This was to render non-toxic the aluminium which might be toxic in such highly acid samples. Padi seeds were planted but again growth was very poor.

The next step was to add lime, as calcium oxide, to the soils at a rate equivalent to 10 tons per acre of burnt lime. Padi seeds were once again sown and this time they grew well except on one soil. Thus it would appear that liming succeeded in counteracting the toxic constituents in the soils.

The best way to dispose of the sulphur is by washing it out of the soil by way of drainage waters. To do this it must first be oxidised to a soluble form. Drainage will thus serve the purpose of aerating the soil, oxidising the sulphur and washing out the sulphates. From a theoretical point of view, drainage, if carried out at all, should be efficient and deep. If drainage of the top soil is good, the sulphur in the upper

Table IV.

Percentage Sulphur in *Gĕlam* Roots and Stems and in Other Swamp Species.

Origin of sample.	Description.	Percentage total sulphur.
Duyong, Malacca	Stem of *gĕlam*	0.212
	„ „ „	0.184
„ „	Roots „ „	0.289
	„ „ „	0.245
Tanjong Minyak, Malacca.	Stem of *gĕlam*	0.144
	„ „ „	0.181
„ „ „	Roots „ „	0.144
	„ „ „	0.224
Megat Dewa, Putat, Kedah	Stem of *gĕlam*	0.070
„ „ „ „	Roots „ „	0.124
Batu Lima, Sanglang, Kedah	Stem of *gĕlam*	0.096
„ „ „ „	Roots „ „	0.146
Gual Periok, Kelantan	Stem of *gĕlam*	0.096
	„ „ „	0.045
„ „ „	Roots „ „	0.102
	„ „ „	0.046
Kuala Nerus, Trengganu	Stem of *gĕlam*	0.087
„ „ „	Roots „ „	0.122
Batu Rakit, Trengganu	Stem of *gĕlam*	0.120
„ „ „	Roots „ „	0.199
Klang, Selangor.	Meranti bakau (timber) (*Shorea Thiseltonii*)	0.004
„ „	Terentang (timber) (*Compnosperma auriculata*)	0.016
„ „	Melawis (timber) (*Madhuca sericea*)	0.005
„ „	Kempas (timber) (*Koompassia malaccensis*)	0.036
„ „	Penarahan (timber) (*Myristica* & other Sp.)	0.022

horizons will be oxidised to form water-soluble sulphates which would be washed down to the lower horizons. If the drainage of the sub-soil is not sufficient to get rid of the water-soluble sulphate, then in subsequent flooding of the area, as in *sawahs*, the sulphate-containing solution would rise towards the surface and, under the reducing conditions brought about by flooding, be reduced to toxic sulphides. The cycle, organic sulphur

compounds—sulphur—sulphuric acid—sulphates—sulphides, could thus be set up and there would be a change from the relatively harmless organic sulphur compounds to the harmful sulphides.

Sulphur out-go is accelerated by moderate supplements of all liming materials, particularly magnesic compounds, as has been shown by lysimeter experiments. Wiklander (12) studied the effect of lime on the production of sulphate in the Gyttja soils of Sweden. Liming at the rate of 20 tons per hectare stimulated the oxidation of the sulphur compounds to sulphuric acid to such an extent that at the end of three weeks the limed soils had actually a lower pH value than the unlimed soils. If very heavy dressings of lime at the rate of 85 tons $CaCO_3$ per hectare were added, then the acidity did not increase, the additional lime being sufficient to neutralise the acidity. The authors point out that in practice, if a sulphurous soil is to be brought into cultivation in a short time, it may be more economical to use only a relatively small amount of lime thereby accelerating the sulphate formation. After the sulphuric acid is leached out an additional moderate liming may be sufficient.

Kivinen (7) carried out a long-term experiment in Finland on the "alum" soils which showed good results with an application of lime at the rate of 4,000 to 6,000 kgs. per hectare (1½ to 2½ tons per acre) for the first year and then 2,000 to 4,000 kgs. per hectare for the succeeding years.

It is reported that not only is the liming useful in counteracting acidity but the calcium also depresses the uptake of sulphur by plants. The author maintains that drainage and lowering of the water table are necessary measures and that liming is also absolutely necessary for their successful reclamation.

Discussion.

The acreage of *gĕlam* is not accurately known but a figure of 80,000 acres has been suggested. It is found mostly in the Settlement and States of Malacca, Kedah, Perlis, Kelantan and Trengganu, but the reputation for toxicity of *gĕlam* soils has been confined mostly to Malacca and Kelantan. In Malacca, however, the failure of crops can also be attributed to bad cultivation and pest damage.

A sufficient number of soils has not been examined to say definitely that sulphur is responsible for the toxicity of certain *gĕlam* and swamp soils. However, the sulphur content of some high yielding padi areas in Krian which were formerly mangrove was found to be quite low as was that in soils from the Tanjong Karang area of Selangor. The results show that while certain of the *gĕlam* soils contain large amounts of sulphur others contain very little, though the reason for this is obscure. It is probably due to the manner in which the alluvial soils were laid down and is certainly not the result of the *gĕlam*. There is no doubt that large amounts of sulphur are toxic to most plants either because of the sulphur itself or due to its secondary effects, i.e. high acidity. Robinson (9) states that hydrogen sulphide in all concentrations is very poisonous to

plants, though it can never reach a high concentration if there is an excess of iron and other bases in solution. In the presence of carbonic acid however, sulphide concentration becomes greater due to the increased solubility of ferrous sulphide.

Apart from the direct toxic effect of sulphur itself there are the secondary effects which can be brought about through the formation of sulphuric acid when the soil is aerated and the sulphides oxidised. The higher acidity leads to greater solubility of aluminium which is known to be toxic to plants. Magistad (8) produced data, relating to the solubility of aluminium in water and soil solution, to show that at pH 5.0 there is 1 to 2 p.p.m. of aluminium in solution. As the acidity decreases to the neutral point the solubility decreases to almost nothing. When the acidity becomes greater than pH 5.0 the solubility increases rather rapidly until pH 4.5 is reached, at which point the solubility increases very rapidly. Thus pH 5.0 is the critical pH where aluminium toxicity is concerned. That there are large amounts of easily soluble aluminium in some of these soils was shown for the Paya Besar soils, where certain samples contained up to 0.3 per cent. of aluminium soluble in 0.5 per cent. acetic acid. Thus if the pH of the soil is raised above 5.0 by liming, aluminium toxicity should be considerably reduced.

Another point to be considered is the action of free sulphuric acid on soil minerals. These minerals, especially calcium and potassium, are converted from insoluble compounds into more or less soluble salts. Potassium especially, would form the very soluble potassium sulphate and, if good leaching and drainage conditions are maintained, a very considerable loss of potash could take place. It is possible that in some of the coastal clays as much of the potash of the soil is lost in this way as is taken up by the plant.

In conclusion it may be stated that while the results do not prove beyond all doubt that sulphur is solely responsible for the toxicity of certain soils, they nevertheless show that its presence is a factor to be considered in opening up areas, especially those covered with *gĕlam*. They give an indication of the reason why padi fails on some former *gĕlam* areas while on others it grows quite well even amongst the *gĕlam* itself, as in the Kubang Pasu area of Kedah. If examination of an area reveals a high sulphur content then extra care should be taken to see that proper drainage is provided in order to wash out as much of the toxic sulphur as possible.

Summary.

The occurrence and characteristics of the "*gĕlam*" tree (*Melaleuca leucadendron*) have been discussed and one of the problems of toxicity connected with *gĕlam* soils, namely high sulphur content, has been investigated.

Some of the work on sulphur in soils of other countries has been reviewed and the manner of its occurrence and oxidation indicated.

The present investigation includes the measurement of the increase in sulphur content and conductivity of soil samples on drying, the total

sulphur content of samples from a number of profiles in *gĕlam* and other soils and the determination of sulphur in *gĕlam* and other species of timber growing in swamps.

These results show that certain *gĕlam* soils contain as much as 6 per cent. of sulphur at a depth of 18 ins. from the surface while other *gĕlam* soils contain scarcely any sulphur. There is also quite a wide variation in the sulphur content of *gĕlam* from various areas.

Ways and means in which highly sulphurous soils might be treated in order to decrease their toxicity are indicated.

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NOTES ON CURRENT INVESTIGATIONS, OCTOBER TO DECEMBER, 1951.

Compiled by the Acting Chief Research Officer and the Senior Agricultural Officer (Research).

Padi.

1. RESEARCH.

Variety Trials.

Analyses of all variety trials carried out to-date were completed by the end of November. A full report on yield data from the 1947-50 series of trials has been submitted. As a result of these trials it is clear that in certain padi areas appreciable increase in yield should be possible by the more extended use of varieties introduced from other parts of the Federation. Recommendations have been made accordingly for the consideration of the Field Branch of the Department.

Variety Selection.

Records of 1950-51 selection experiments are still in process of analysis. The 1951-52 programme is proceeding normally. New selection work, commenced this season, comprises 1,010 ear rows of Anak Naga planted at Kota Bharu Experiment Station and a foundation stock of Mayang Sa Gumpal at the new Station at Jelawat in Kelantan.

Hybridisation.

F1 plants from crosses carried out last season have all flowered. About a third of these show evidence of hybridity. A few plants were damaged by rats and a number of *pianggang* but a satisfactory quantity of good seed should be obtained. Of one cross, two plants with a maturation period of 156 days have been reaped.

Plant Analyses for Examination of Soil Fertility.

Previously, mature padi plants from a manurial experiment at Bukit Merah were analysed to find out some facts about their uptake of nutrients. Information from other countries suggests that the best method and time to analyse cereal crops, if the soil fertility is being examined, is analysis of the leaf at flowering time. The amount of K_2O, CaO, P_2O_5 and MgO in the leaves at this period is reported to give a very good indication of the fertility of the soil and to suggest which nutrients may be lacking. Consequently, samples of padi leaves have been obtained from certain areas in Malacca and Negri Sembilan where the yield of padi is known and these have been analysed for the various nutrients. Although a considerable variation has been noted there does not appear to be any connection between yield and nutrient content of the leaves. Many more samples will need to be analysed before any definite conclusions can be reached.

Hydroponic Experiments with Padi.

As a consequence of the results noted in the previous quarterly report, it was decided to try to discover if it would be possible for padi to continue its growth without aeration if given a start in aerated solution. Consequently, after 4 weeks growth, aeration of six of the plants was stopped and aeration of the other six continued. The plants were grown until flowering commenced, then they were taken out of the solution for determination of the nutrient content of the leaves.

Growth of the aerated and non-aerated plants was equally good. This shows that, although padi cannot grow without an oxygen supply to the roots, when once a vigorous leaf growth has been developed, growth proceeds without aeration.

Another experiment was set up in which soil from a padi *sawah* was made into a slurry and placed in beakers and small padi seedlings planted. These suspensions were not aerated. The plants grew to a certain extent but were stunted; consequently, nutrient solution was added to all the beakers and half of them were aerated. The aerated plants grew very much better and the difference in colour is quite noticeable, the aerated plants being dark green and the unaerated plants a much paler colour. This shows that even in mud, aeration is necessary in the early stages of growth.

Pest Control.

STEM-BORERS.

Regular samples of bored padi stems have been received from Jasin during the quarter. In many cases the borers had left, but in those cases where borers were still present, *Schoenobius* far outnumbered other species.

A trial was made with a BHC wettable powder to see whether it would give any protection against stem-borers. One month after treatment, it was found that the Controls showed 77.8 per cent. of the stems bored against 48.4 and 39.5 per cent. bored in the two series of sprayed plants. The effect was not lasting, however, and a month later all plants showed the same order of attack.

Laboratory trials with the Tachinid fly *Paratherasia claripalpis* v.d. Wulp, a parasite of sugar cane borers in South America, to see if it could develop in any of the local padi borers, were sufficiently encouraging to warrant further work. It is hoped to try a field liberation in 1952.

SCOTINOPHARA.

An outbreak of *Scotinophara coarctata* F. was reported from Perak riverine mukims in October. The Senior Entomologist visited the area and recommended the application of a dust of equal parts 5 per cent. DDT and Agrocide 3. Nurseries of wet padi, and a number of scattered areas of dry padi were affected, maize also being attacked in the dry padi areas. Application of the dust was demonstrated and the importance of treating the nurseries before transplanting was stressed.

Disease Control.

A specimen of padi plants from Jementah Agricultural Station was attacked by four fungi—*Cercospora oryzae, Rhizoctonia solani, Piricularia oryzae* and an unidentified agaric. *Rhizoctonia* and *Piricularia* appeared to be causing most damage, in the form of killing of tillers and rotting of leaf sheaths.

2. Agronomic Investigations.

Wet Padi.

Reports have been received that, in the current series of manurial experiments, responses to treatments have been shown in most trials by more vigorous vegetative growth. This has been most marked in the case of soluble nitrogenous and phosphatic fertilisers applied to the relatively infertile soils of Kelantan and Trengganu. However, it would seem that a response in vegetative growth is also being obtained in Malacca, parts of Perak, Pahang and on the rich soils of north Kedah. Since this series of experiments will be continued for a total of three seasons the investigations should yield results of very great value.

In the type and depth of nitrogen series it has been noticed, at two sites in Kedah and also at Kuala Kurau, in Perak, that the vegetative response to an application of sulphate of ammonia was superior to that from an equivalent dressing of nitrate of soda. This observation conflicts with some results obtained last season.

It has been noticed in Kelantan particularly, but also at Bruas in Perak, that a heavy application of soluble phosphate, applied before transplanting, generally leads to vigorous growth followed by yellowing of the foliage, such yellowing being completely curable by a placement application of nitrogen. A comparable observation has been made in Kedah where, in a simple type of phosphate experiment, no response to this nutrient was obvious until after a top-dressing of nitrogen had been applied some eight weeks after transplanting.

In the large series of manurial trials which were planned for smallholders' land in Kelantan, a total of 265 experiments have been laid down. The standard dressing consists of 200 lbs. per acre of a fertiliser containing sulphate of ammonia, double superphosphate and muriate of potash analysing 11.5 per cent. nitrogen, 9.9 per cent. phosphoric acid and 12.3 per cent. potash. The treatments are as follows:—

A. One unit of fertiliser applied before transplanting and cultivated into the soil.

B. As in A with a second unit applied by placement 6 to 8 weeks after transplanting, i.e. a total of 400 lbs. per acre.

C. Control—no manure.

D. One unit applied by placement 6 to 8 weeks after transplanting.

Even with an early application of this complete dressing preliminary observations have indicated that the available nitrogen is rapidly used up and that a period of rapid growth and tillering, when the plants are a deep green colour, is followed by yellowing of the foliage, and the degree of yellowing is more severe than in the surrounding fields of unmanured

padi. This would seem to indicate that, for Kelantan conditions, the standard dressing should perhaps contain a higher proportion of nitrogen. However, more light will be thrown on this problem by results from factorial experiments which are now in progress in two localities in Kelantan.

At Paya Besar, Pahang, three agronomic trials have been wiped out by rats because the experimental area is surrounded by uncultivated land. Investigations in Johore are also handicapped by similar conditions.

Dry Padi.

In a complete mechanisation trial at Melor, in Kelantan, the harvest prospects are reported as excellent. Cultivation, drilling and weeding were all mechanised and it is planned to mechanise the harvest.

Very marked responses have been noticed in manurial trials and there is some indication that, for dry padi, a slowly-available phosphatic fertiliser may give a better result than a soluble one. In factorial trials at Kg. Pusu and Melor the heaviest complete fertilisers are generally giving the best response but there is no indication that minor elements are limiting yields.

Cacao.

1. RESEARCH.

Amelonado.

A policy of multiplication of Amelonado by every possible means has been agreed. A labour force of one Agricultural Subordinate and

	Stock at F.E.S., * Serdang.	Sungei Udang.	Jerangau Estate.	F.E.S., Jerangau.	Degong.	Bukit Mertajam.	Total.
Seedlings	66	—	—	—	—	—	66
Cuttings	122	—	197	260	—	—	579
Buddings	—	182	502	—	107 + 500	50	—
Unions	—	156	389	—	93	—	—
Per cent.	—	86	77	—	87	—	—
Final success	—	124	—	—	—	—	124
Per cent.	68	—	—	—	—	—	—
Total plants	188	124	197	260	—	—	769

* Federal Experiment Station.

Unions which have not yet shot have not been included in the totals.

ten labourers started work on the 12th November, 1951. Their primary task is the multiplication of Amelonado cacao.

A summary of the progress made is given in the above table.

The four plants in the Amelonado seed garden are flowering freely and four pods have been harvested. Further pods are nearing maturity but monkeys have stolen at least three pods.

Trinitario.

Ninety-six cuttings from six Serdang-Cheras clones were distributed for a clonal block on Jeram-Kuantan Estate. Cuttings for further blocks are in stock.

Supplies for the clonal trial at the Federal Experiment Station, Serdang, were provided.

Further cuttings from the six selections at Kinrara have been taken with a view to planting a small clonal trial. Five cuttings from each selection were despatched to Jerangau Estate.

Basketed buddings from 75 East Indian progeny seedlings were despatched to Jerangau Estate and a further 80 are almost ready for collection.

General observations are being maintained on about 23 different imported Trinitario progenies and on about 20 legitimate progenies from local trees. The I.C.S. 1 clonal seedlings received via Kew are flowering and a few cherelles have been produced.

Criollo.

The illegitimate Criollo progeny trial in Field 43 has not maintained its early promise. There are, however, a few good plants.

Criollo cacao is proving less vigorous than Trinitario in a comparative trial. Growth in this trial ("jungle planted") is satisfactory.

Techniques.

The technique used for budding cacao is proving satisfactory provided the stocks are healthy and vigorous.

A diesel engine has been installed in the open air cuttings propagator and the electric engine is now used as a standby. This will eliminate break-downs which have spoilt various experiments in the past.

Sawdust has proved a satisfactory rooting medium in the Trinidad type propagators. In the continuous spray propagator, sawdust quickly deteriorates and becomes "soggy".

Coir dust has not proved as successful in the continuous spray propagator for the same reason.

A mixture of sand and coir dust is giving good results but has not yet been used on a large scale.

Pest Control.

Damage to older seedlings by the red coffee borer *Zeuzera coffeae* Nietn. has been reported from Kelantan and Perak. Injection into the

holes of a few cubic centimetres of orthodichlorobenzene or a pyrethrum solution is a simple control measure. So-called shot-hole borers (Ipid beetles) were reported from these same areas injuring the stems. Against the mosquito bug *Helopeltis theobromae* Miller, dusting with a BHC powder, preferably from an engine driven duster, is recommended.

2. Agronomic Investigations.

With the advent of wet weather in September all cacao at Serdang has shown a marked improvement in growth and most fields are now adequately shaded. Growth of West African Trinitario has been particularly good in Field 49. An important seed multiplication block of West African Amelonado has shown considerable recovery from the dry weather damage reported last quarter and many trees are now flowering and fruiting. A contemporary planting under jungle shade is healthy and vigorous but no flowering has yet been observed.

A small block of New Guinea Trinitario was planted out in October and trees appear to have established well.

Two establishment experiments on estates and one on an Agricultural Station have been discontinued on the grounds that no further useful information could be obtained economically.

A small observation on Gajah Mati Agricultural Station, Kedah, is indicating that the top shade requirements of cacao in north Kedah may be less than in the equatorial region further south.

A very successful establishment experiment at Degong Agricultural Station, Perak, has been discontinued and 527 plants have now been budded with Amelonado to act as a seed multiplication nursery.

At the new Federal Experiment Station, Jerangau, in Trengganu. opening up continues and a 15 acres block has been almost completely fenced and a 4 chains long access road constructed. Some 3,800 Trinitario seedlings have been transplanted into baskets and 230 Amelonado cuttings and budded plants have been established in the field under thinned jungle shade.

Oil Palm.

1. Research.

Selection and Breeding.

Dumpy Palms (E.206).

In accordance with the policy of developing the dumpy palm, a progeny trial containing 420 seedlings (plus guard rows) was planted at Ulu Bernam. The seedlings were about 18 to 24 months old. The progenies are the result of crosses made between some of the best dumpy palms in the F1 at the Federal Experiment Station, Serdang.

A second progeny trial of 420 seedlings was also planted at Ulu Bernam. These progenies are of the type (E.206 selfed) x (E.268 x E.206).

Nurseries containing legitimate dumpy seedlings have been completed at the Federal Experiment Station, Serdang, and on five estates. Field planting will take place next year.

PISIFERA—TENERA PALMS.

In accordance with the policy of investigating the possibilities of tenera palms, action has been taken as follows:

Pollen has been collected from two fertile pisifera palms at Serdang (29|36 and 36|21) and will be used on selected Deli palms.

Seed from pisifera 29/36 has been germinated. Although the germination was poor (about 20 per cent.), it has been shown that it is possible to raise seedlings from this palm. The palm will accordingly be selfed and it is hoped that the progeny will consist of fertile pisifera palms. These should be of considerable value for crossing on to Deli palms with a view to producing tenera palms.

The tenera x tenera seedlings raised from Nigerian seed are progressing well but the dura x pisifera seed has not germinated satisfactorily.

Seed produced by crossing selected Deli palms with pollen from pisifera and tenera palms at Serdang has also germinated and will be planted and included in the same nursery.

Leaf Analyses.

The Senior Chemist has found marked differences in the composition of the leaf samples taken from three of the Elmina progenies.

The results of these analyses which have been carried out at 3 monthly intervals since the 14th March, 1950, have been analysed statistically. The results show that for CaO, families 97 and 207 are significantly higher than 268. This corresponds with the analysis for bronzing, family 268 having the least bronzing and thus showing that CaO is directly related to bronzing. On the other hand, K_2O is significantly higher in 268 than in 207 and 97, showing that potash is inversely related to bronzing. For the K_2O/CaO ratio $268 > 207 > 97$ and is thus inversely related to bronzing. P_2O_5 and MgO are not directly related to bronzing but for the K_2O/P_2O_5 ratio $268 > 207 > 97$ again showing that this is directly related to bronzing. There is a negative correlation between K_2O and CaO showing an antagonism between these nutrients. Consequently, there has been a very considerable decrease in the K_2O/CaO ratio. Work is proceeding.

Determinations of N, P_2O_5, K_2O, CaO and MgO have been carried out on the leaves of young oil-palms grown for 5 months in hydroponic solutions. The experiment consisted of growing them in four sets of three plants, each set having a solution with a different K_2O/CaO ratio, varying from high to low. The results show that there is not a very large decrease in the amount of K_2O in the ash of the leaves when the K_2O supply is decreased, but there is a very considerable increase in the CaO content with low potash and high calcium supply. The ratio K_2O/CaO in the ash varied from 5.29 for the high K_2O/CaO to 2.24 for the low ratio.

Pest Control.

BAGWORMS.

It is reported that an outbreak of bagworms in the Klang area now seems to be under control. The Department lent its Dustejector

motor duster to the Estate in question and BHC dust was used for control in addition to a BHC wettable powder sprayed with the Estate's own equipment.

2. Agronomic Investigations.

In a replanting experiment at Serdang palms in three replicates were felled in October, 1951, one year after interplanting with young palms. Felling was carried out with a D.8 Caterpillar tractor with stumper attachment, and the combination was found to be very efficient. Under favourable conditions a palm could be felled in 20 seconds, the average time taken being 45 seconds, although this naturally excludes the period of movement between different plots. Palms near drains or other obstacles, which could not be pushed down, were pulled out using an H.D.10 tractor and winch. Only a few young palm seedlings were damaged, mostly by being hit with fronds of falling old palms.

In this trial two methods of windrowing were adopted. On undulating ground the palms, as they were felled, were windrowed between rows of young palms as an anti-erosion measure. On flat land, two rows of mature palms were pushed into a single windrow, thus permitting subsequent mechanisation of cultivation and harvesting.

A layout for a factorial manurial experiment has been prepared for an estate in Selangor. The treatments include all combinations of presence or absence of nitrogen, phosphorous, potassium and magnesium.

Coconut.

1. Research.

Selection and Breeding.

Final selection of parental palms at the Federal Experiment Station, Port Swettenham and Carey Island has been made. Commencement of breeding work awaits the acquisition of suitable apparatus to provide access to the inflorescences, or decision on alternative programme without controlled pollinations.

Pest Control.

The beetle *Promecotheca cumingi* Baly (Philippine leaf-miner), which was found in Singapore earlier in the year, does not seem to have extended beyond the area reported in the April issue of the Journal, and it is hoped that the parasites have now established control.

2. Agronomic Investigations.

With the closing of the Federal Experiment Station, Port Swettenham, two mechanical cultivation experiments have been discontinued. This station was required urgently for resettlement of squatters.

A factorial manurial trial at Serdang was planted up early in the quarter and subsequent growth has been satisfactory.

Fibres.

1. Research.

Ramie.

Analysis of results of yield of the second crop of the trial of 16 clones at the Federal Experiment Station, Serdang, is not yet complete. A third crop is soon to be harvested. It is intended to arrange for yield trials at several stations of the five to six selections which prove most promising in the trial now in progress.

Ramie on Peat.

The ramie crop in the peat pot experiment has been harvested, the highest yield being obtained in the lime + N.P.K. pots. Even so, the crop was far from satisfactory as the plants only grew to a height of 3 ft.

2. Agronomic Investigations.

In a time of planting experiment of jute at the Federal Experiment Station, Kuala Lumpur, the first block was sown in November with plots of both *Corchorus capsularis* and *C. olitorius*. Sowings are being repeated every month for one year in order to study possible photoperiodic or other climatic effects on growth and maturation period. Results from this crop have been somewhat disappointing because of the early onset of flowering.

In a factorial manurial experiment of ramie on peat, growth has been quite good wherever adequate nitrogen has been supplied.

A large drainage and variety trial of Manila hemp has been discontinued with the closing down of the Federal Experiment Station, Port Swettenham. The soil on this station is an impervious, heavy clay and growth of Manila hemp showed very little promise.

At the suggestion of a local planter, seed of New Zealand flax. *Phormium tenax,* has been imported and sown at Cameron Highlands Agricultural Station. Germination was good.

Roselle hemp, *Hibiscus sabdariffa,* has grown well in Kelantan but the maturation period is too long for it to be used as an off-season crop on padi land.

Tea.

1. Research.

Selection.

Preliminary field selection of tea bushes has been completed and the next stage is to be based on the results of rooting trials. During November, 19,856 cuttings of 224 of these 264 preliminary selections were planted; 40 bushes had no suitable wood for cuttings. This averaged 89 cuttings per bush as compared with the target of 200. A second series of cuttings will be taken early in 1952.

Disease Control.

BLISTER BLIGHT.

So far, less damage has been done in the highlands than in the corresponding period last year. There has been a gradual build-up during the quarter but fairly frequent sunny mornings have helped to some extent to keep infection down.

This disease has not again been recorded on the lowlands and it is unlikely that serious damage will occur there.

One control by spraying experiment has been completed at the Agricultural Station, Cameron Highlands; it was designed to discover whether it is advisable to add stickers and spreaders to Perenox. Weather during the experiment was rather dry and sunny, so infection even on unsprayed plots was not heavy.

A further eight spraying experiments have been laid down and will be completed by March, 1952. These are to compare different fungicides (copper-based and organic), different strengths and volumes of spray, and different spraying intervals to find the effect of weed growth on disease incidence and the effect of additives on the control obtained with Shell Copper Fungicide. In addition, two experiments previously started (effect of pruning at different times of the year and loss of crop due to blister blight) are being continued.

Copper Content of Leaves. (re Fermentation).

Monthly determinations of the copper content of tea bushes grown on soil sprayed with copper sulphate solution have been carried on. This experiment has now been continued over a period of three years. It is apparent from the results that no great increase in the copper content of tea leaves can be induced by spraying the soil around the bush. Another area of Field 6A has been chosen for treatment on a larger scale. Enough bushes have been included in the sprayed area to give a sufficient supply of leaf for made tea at the Serdang factory. By such means it is hoped to compare the qualities of treated and untreated teas. As a preliminary, the copper content of the leaves is being determined at monthly intervals over a period of 6 months, before spraying.

2. AGRONOMIC INVESTIGATIONS.

Two tea rooting experiments have been completely supplied during the quarter. These are now in their third year and figures for total casualties indicate that cuttings are as easy to establish as seedlings. However, the high casualty rate indicates that, on poor soil, replanting of tea will always be an expensive operation, and manuring with cattle manure in the planting holes will be essential.

Mistakes have been made in the field application of fertilisers to a tea manurial experiment at Cameron Highlands. The crop is now being pruned and the first year's yields will have to be ignored.

Rooting trials of selections have commenced at the Cameron Highlands Agricultural Station.

Pineapple.

1. Research.

Pest Control.

Parathion was tested against the mealybug *Pseudococcus brevipes* Ckll. on pines growing in nutrient solution. A proprietary brand was used and the treatment was applied on 18th August, when there were about 50 mealybugs per plant. The formulations used were a dust of unspecified toxicant content, a wettable powder of 0.4 per cent. parathion in the final spray, and a solution of 0.2 per cent. parathion in the final spray.

The results showed a good initial kill of mealybugs, with the dust giving the best result followed by the 0.2 per cent. spray and the 0.4 per cent. wettable powder respectively, but there was no evidence of systemic effect.

2. Agronomic Investigations.

A small paper mulching experiment was laid down in Kuala Lumpur in October in order to study the effect of this type of mulch on growth and yield of pineapples and to determine the effective life of such a mulch. Early observations suggest that this type of paper rapidly loses texture and is soon penetrated by sedge seedlings such as Nut Grass, *Cyperus rotundus.*

In a manurial experiment on peat in south Johore, loss from fruit rot in the plant crop was about 30 per cent.

Five new manurial experiments have been laid down during the quarter, on peat soils of Johore.

A 20 acres block of the new Federal Experiment Station, Alor Bukit, in the Johore pineapple area, has now been drained but *belukar** is being allowed to grow up in order to complete burning of timbers satisfactorily in July-August.

Fodders.

1. Research.

Fodder Grass Experiments.

Monthly analyses of samples from the Guinea grass experiment continue to be carried out. The values show that the samples from plots with 8 and 10 cwts. sulphate of ammonia per acre are consistently higher in protein than those from the other plots. The controls average about 8.8 per cent. protein on a moisture free basis while the 10 cwts. per acre plots average about 12 per cent. The amount of sulphate of ammonia does not appear to have any effect on the calcium content of the grass.

Samples of Napier grass from plots receiving 10, 15 and 20 cwts. per acre sulphate of ammonia are also being analysed. The results show that it is possible to increase the protein content up to the region of 16 to 17 per cent. on a moisture free basis in the heaviest manured plots.

* Secondary jungle growth.

2. Agronomic Investigations.

Fodder Grasses.

In a Guinea grass irrigation and manurial experiment at Serdang, the first fertiliser application was given in September and experimental irrigation commenced in the same month. There has already been a marked response in yield from the manures and a smaller one from optimum irrigation.

An intercultivation experiment on Guinea grass was planted early in the quarter and pre-treatment yields are now being recorded. The object of this experiment is to determine whether the root pruning associated with deep mechanical intercultivation has a beneficial or harmful effect on growth and yield of Guinea grass.

Leguminous Fodders and Green Manures.

Yields of Stylosanthes are being well maintained in Kelantan except on one station where cutting was considered to have been too low. Monthly production of fresh fodder per acre at Melor Agricultural Station is given below:—

Month		Yield per acre	Rainfall in ins.
September	....	6,669 lbs.	9.95
October	....	6,644 ,,	14.48
November	....	4,525 ,,	10.14

The allied species *S.sundaica* has been re-imported for more extensive trials of its usefulness under a wide range of conditions.

The small leguminous tree *Indigofera teysmanni* grows to a height of 6 to 10 ft. in Selangor and is now flowering heavily. This should be a useful introduction provided that seed is produced in sufficient quantity. Another recent importation which promises to be very useful is *Sesbania speciosa*, seed of which was introduced from Madras.

The upland creeping cover *Eupatorium riparium* has now been established at Cameron Highlands Agricultural Station where it will be tested as a ground-cover for young tea. Initial growth has been good. A variety of forage legumes with a clover-like habit are under observation at Cameron Highlands. None so far has shown as much promise as clovers.

Pastures.

Agronomic Investigations.

The factorial manurial experiment at Serdang which was mentioned last quarter has now been commenced and the first application of fertilisers was given in November.

In a shade and variety trial at the same locality yields from *Axonopus affinis* have been higher in the first two years than from *A.compressus* and it is evident that the former species yields better in the open than under shade.

Fruit.

1. Research.

Cashew Nut.

A small investigation into the extraction of shell oil from the shells of cashew nuts has been carried out. It was found that several solvents including ether, trichloroethylene and carbon tetrachloride could be used to extract the oil and that the important factor was to crack and break the shell to allow penetration of the solvent. The investigation was in connection with an estate in Province Wellesley which has a 400 acres plantation of cashew nuts and a factory in which, however, they have not yet succeeded in extracting the shell oil.

2. Agronomic Investigations.

A factorial manurial experiment with bananas has been laid down at Ampang Tinggi in Negri Sembilan. Holing for planting and cultivation was carried out mechanically and the whole area was sown with a leguminous creeping cover. Planting of banana suckers commenced towards the end of the year.

A banana pruning experiment was planted in the Federal Experiment Station, Kuala Lumpur, in October, using *Pisang Embun*, and early growth has been good.

Vegetables and Foodcrops.

1. Research.

Vegetables at Cameron Highlands.

Carrots.

Twelve varieties of carrot are being grown at Cameron Highlands to compare their resistance to leaf blight (*Alternaria dauci*). Because of wet weather, attack has started within six weeks of planting and already differences in resistance are apparent. A second spraying trial against the same fungus has been laid down but spraying has not yet commenced.

French Beans.

A trial to discover whether good control of anthracnose (*Colletotrichum lindemuthianum*) can be obtained with three copper sprays (Bordeaux mixture, Perenox and Shell Copper Fungicide) is in progress.

Celery.

A trial to compare the control of leaf spot (*Septoria apii-graveolentis*) obtained by spraying at 7, 10, and 14 days intervals with Perenox has been laid down and spraying has been commenced. *Cercospora apii*, another cause of leaf-spotting of this crop, has been observed but is of no significance compared with *Septoria*.

Lettuce.

A certain amount of damage is done by bottom rot, caused by *Rhizoctonia solani*, throughout the year but during this quarter the disease

has been severe and many lettuces on the Agricultural Station have been completely killed. A small observation trial in which soil treatment with Perenox was tried gives some indication that control might be obtained in this way.

TOMATOES.

Blight (*Phytophthora infestans*) completely destroyed a planting of tomatoes on the Experiment Station despite frequent spraying. Attack began just over three weeks after planting.

Foodcrops.

GROUNDNUT.

A foundation stock of 15 collections of groundnut strains has been planted at the Federal Experiment Station, Kuala Lumpur, with a view to carrying out pure line selection for yield etc.

SOYABEAN.

Selection plots of recent Java introductions have just been harvested and recording of yields etc. is in progress.

A soyabean trial was set out in peat pots, no additional manurial treatment was given, but a small quantity of soil was added to each pot. This was taken from a bed in the Experimental Station where soyabeans had previously been planted. This was done since it was suspected that the soyabeans had failed the previous time owing to lack of the appropriate micro-organisms. In this trial, the soyabeans grew well on the limed pots but failed to bear any seed.

2. AGRONOMIC INVESTIGATIONS.

Variety trials on soyabeans and groundnuts at the Federal Experiment Station, Kuala Lumpur, were harvested during the period under review. The soyabeans gave yields varying from 526 to 926 lbs. of dry seed per acre. The average for the previous crop, harvested in drier weather, was 1,245 lbs. per acre with a maximum yield of 1,428 lbs. per acre.

In the groundnut trial, seven varieties yielded more than 2,000 lbs. per acre of dried, shelled beans. The imported strains Jumbo Virginia and Spanish gave significantly lower yields and have, therefore, been discarded.

In a variety and time of harvesting experiment on tapioca which was concluded recently at Melor, in Kelantan, the varieties Kekabu and Medan out-yielded all other varieties with a crop of 9.5 tons of tubers per acre. Significantly higher yields were obtained from harvesting at 12 and 14 months after planting as compared with 10 months but there was no difference between harvesting at 12 and 14 months. Since the variety Kekabu is also the most palatable one it is the obvious choice for planting by smallholders.

Miscellaneous Crops.

AGRONOMIC INVESTIGATIONS.

Tetracarpidium Conophorum—Conophor Nut.

Plants at Serdang are now flowering heavily but no seed has been set yet. Flowers are unisexual-monoecious but very few female flowers are produced. Young plants have been found to be easy to establish provided that they are protected from snail damage in the very early stages of growth.

Soils.

RESEARCH.

Padi Soils.

SULPHUR IN *GELAM* SOILS AND *GELAM* WOOD.

A number of timbers and roots from *gĕlam* trees have been obtained from Malacca, Kedah, Kelantan and Trengganu and sulphur has been determined in these. The Malacca samples were found to have the highest, 0.25 per cent. being recorded; most of the others were under 0.1 per cent. with the exception of one series of samples from the Batu Rakit area of Trengganu where the value was nearly 0.2 per cent. The high values for sulphur in the *gĕlam* timber correspond to the poorer areas of *gĕlam* soils as regards padi cultivation. A further series of soil samples from Duyong and Pulau Gadong, Malacca, have been analysed for sulphur. The Duyong area has been found to be generally low in sulphur with values of the order of 0.2 to 0.4 per cent. S., nevertheless, the *gĕlam* wood contains as much sulphur as the Tanjong Minyak area near Pulau Gadong where over 6 per cent. of sulphur was found in some of the soil samples. This is the highest value yet recorded for Malayan soils. It is obvious from these results that there is considerable variation in the sulphur content of *gĕlam* soils. This may be one of the reasons why padi grows successfully on some *gĕlam* soils while on others it is almost a complete failure. Results of this investigation are being published.

Peat Investigation.

LABORATORY INVESTIGATION.

Samples of peat from pots which had received lime at various rates and also N.P.K. and copper sulphate have been analysed. Liming at rates of 5, 10 and 20 tons per acre caused a considerable decrease in the amount of ammonia-soluble fraction in the peat but resulted in a relative increase in the percentage of lignin. It was noted during these experiments that the limed peat assumed a much blacker colour than the unlimed material.

Soil Texture.

As reported in the previous quarterly report (July to September), a small pot experiment was set up in which poor subsoil quartzite was mixed with coarse sand in the proportion of ¼, ½ and ¾ parts of sand

to soil and, in addition, pots with soil only and sand only. The purpose of this experiment was to test the theory that the poor growth on this type of soil was due as much to the poor structure as to its poverty in plant nutrients. Tomatoes were planted and the difference in growth was remarkable, the plants in the pots having ½ sand, ¾ sand or pure sand growing to a height of approximately 2 ft. while those in the pure subsoil and in subsoil + ¼ sand grew only to a height of 6 ins. None of the plants bore fruit, but this was probably due to lack of nutrients. In a previous experiment, it was shown that even when a full dressing of N.P.K. + lime was added to the subsoil, plant growth was very poor. Another experiment is being carried out in which the pots of mixed sand and soil are being manured as well to see if full growth can be obtained.

Water Movement in Soils.

The daily observations on the movement of the water table in the wells at the Federal Experiment Station, Port Swettenham, have been carried on for 8 months; they have now been abandoned since the Station is being given up. From the results to-date, the following conclusions can be drawn: a rainfall of 0.5 in. in one day raises the water table in the wells 20, 25 and 30 ft. from the drains, from 15 to 25 ins. Provided there is no further rain the water table falls to its previous level in 2 to 3 days. A rainfall of 0.5 in. causes only a slight rise in the water table in the 5, 10 and 15 ft. wells and it does not take quite so long to return to original level. A heavy fall of one inch or more causes a quick and substantial rise in the water table in all wells but it falls fairly quickly in the 5, 10, 15 ft. wells and somewhat slower in those wells further away from the drain, the latter taking about a day longer to reach their former levels. The results showed that the cambered beds gave the lowest water-table; this was probably due to the cambering of the beds which caused more run-off, so that less water entered the soil.

Mulching at the Federal Experiment Station, Kuala Lumpur.

Monthly examinations of a soil under two types of mulch (saw dust and padi husk) at the Federal Experiment Station, Kuala Lumpur, have been carried out over a period of 9 months. Determinations included pH, moisture content at sampling, water holding capacity, crumb stability, water stable aggregate (mechanical) analyses, organic matter content and nitrogen content.

As measured by the water drop method there was quite a large increase in the stability of the aggregates both in the mulched plots and in the controls. A similar finding was noted when aggregate analysis was carried out, the percentage of water stable aggregates greater than 3 cms. increasing from 0.2 per cent. at the beginning of the experiment to an average of nearly 20 per cent. at the end of 9 months period. The same increase was noted in both the controls and the mulched plots. The inference from these results is that the soil structure has been improved by the presence of these crops; by the roots of the maize, yam, beans

and tapioca; by the canopies protecting the soil from the beating action of rain; by a reduction in soil temperature, and by the penetration of their roots.

Livestock.

Goats.

The following kids have been born at Serdang during the quarter:—

Toggenberg pure-bred	....	1 female.
Saanen 7/8 bred	....	1 male, 1 female.
,, 3/4 bred	....	2 males, 1 female.
Various half-breds	....	8

Seventeen services were carried out by pure-bred bucks.

British Alphine Doe No. 4 again heads the milk-yield with an average daily yield of 6.41 lbs. Total milk yield for the herd was 3,143.5 lbs.

Several half-bred young goats in the Sabak Bernam area of Selangor are now between two and three years old. A study of their growth rates shows that half-breds put on weight much more rapidly than local animals.

Cattle.

The small herd of Bali cattle at Serdang are thriving. These animals are mentioned elsewhere in this Journal.

Poultry.

Feeding trials with Rhode Island Reds and with ducks are in progress in Perak. Results from these trials are showing considerable variation and it is still too soon to draw conclusions from them. Recent results suggest that the inclusion of *Leucaena glauca* meal in the mash improves hatchability, but earlier results suggested the reverse.

In the standard feeding and management trials best egg production has been obtained, in general, from Rhode Island Red birds receiving a Serdang ration. However, in some cases the kampong pens are doing better than Agricultural Station ones.

NOTES ON EXTENSION WORK, SEPTEMBER TO NOVEMBER, 1951.

Compiled by the Acting Chief Field Officer.

Padi.

Selected Seed.

A total of 1,373 gantangs of padi seed was distributed during the quarter. This is almost entirely seed of pre-war selections that survived the occupation. The post-war selection work is not yet sufficiently advanced for seed distribution, although in Malacca and Negri Sembilan one of the selection lines of the variety Serendah Kuning attracted the attention of farmers and a very limited advanced distribution has been made.

Manuring.

Ninety per cent. of the 300 manurial trials planned for Kelantan and Trengganu, and mentioned in the previous issue of the Journal, have been laid down. These trials have been laid down on land worked by the owners themselves and, as expected, there has been difficulty in a number of cases in ensuring that the instructions for the application of the manure were understood and carried out correctly. In general, growth has been excellent and although very few plots have been harvested smallholders have been much impressed with the potentialities of the special mixture which has been used in these trials. Even if these trials confirm fully the early findings of the Department on its own Experiment Stations, it is impossible to estimate with any accuracy the probable demand for manure for the coming season. However, it is considered unlikely to exceed 200 tons.

Mechanical Cultivation.

In Selangor, owing to unusually heavy early rains and the resultant flooding of the Tanjong Karang area, tractors were not used as much as they were in the previous quarter. Other States are preparing schemes for mechanical cultivation of padi and other crops and there will almost certainly be new developments in this work. In Perak, four tractors belonging to the Rural and Industrial Development Authority are being run-in by Departmental operators. Fourteen operators were trained during the quarter and all but three passed their tests.

Rubber.

C.D. & W. Scheme No. D.1176—Supply of Planting Material to Smallholders.

The quarter September to November covered most of the main rubber planting season. The smallholders very much prefer planting

clonal seedling stumps to budding in the field, but supplies are insufficient to meet all demands. There are, however, large surpluses of budwood, and any likely demand can be met. The reasons for this strong preference are easy to to understand; budding in the field requires skill or the hire of skilled labour and a high standard of field maintenance until the buddings are fully established. Distributions of approved planting material from the nurseries maintained by the Rubber Research Institute and the Department during the quarter were as follows:—

Budwood	10,646	yards.
Germinated Clonal Seeds	171,000	
Clonal Seedling Stumps	914,540	

During the recent seedfall, 5¼ million seeds from approved clonal areas have been collected and purchased for planting in nurseries. The plants from these nurseries will be ready for distribution in the last quarter of 1952.

A fourth group of 25 youths has recently completed the course of technical training in rubber husbandry and factory technique at the Rubber Research Institute, Sungei Buloh, and a fifth group of 40 persons is about to be selected to commence training in January, 1952.

Planting Methods.

Most smallholders follow the conventional planting distances, but in some areas progressive farmers are attracted to hedge-row planting. There are trials and demonstrations under smallholding conditions in most States but these are still in their early stages. Although the ultimate benefit that is expected from hedge-row planting is ease of replanting, the prospects of immediate profitable inter-row cropping is the most important factor for the smallholder. Conditions are not always favourable. Much of the old rubber is on land with a difficult gradient where the soils are usually degraded; skilled farming and hard work will be needed to obtain satisfactory results under such conditions. However, some very promising efforts can be seen where fruit trees, cacao, vegetables and root crops have been successfully planted.

Processing and Marketing.

Schemes for centralising manufacture of sheet rubber are under consideration, but most centralised purchasing is still concerned with the bulk purchase of latex by agents or societies on behalf of trading companies. Many of them are running quite smoothly but in others the inevitable difficulty of adulteration has been encountered.

Fruit.

During the quarter, 1,090 budded fruit trees were sold. To meet an increasing demand, mainly for rambutans, all State and Settlement Agricultural Officers are making special efforts to increase their seedling nurseries for subsequent budding.

Cacao.

No major developments in extension. The numerous experimental and non-experimental plots, over a wide range of conditions, are kept under observation by the Field Branch.

Pineapples.

This crop is important in Johore and Selangor only. Post-war plantings of pineapples are mainly confined to the peat and muck soils. These soils present interesting problems and, pending the opening of the Department's Pinapple Experimental Station at Alor Bukit in Johore, the State Agricultural Officers are conducting field experiments in co-operation with estates and smallholders.

Pepper.

An estimated area of 250 acres of pepper is now established in the Johore Bahru district; about 30 per cent. of this is in bearing.

Livestock.

Pigs.

During the quarter, 67 Middle White boars and gilts were sold. At Pulau Gadong Stud Farm in Malacca, 61 services were carried out by the stud boars. A check was made on 57 local Chinese sows and one pure-bred Middle White that had previously been served by the stud boars. They farrowed a total of 658 pigs of which 563 survived, equivalent to 9.7 pigs per litter.

In Penang, whole villages of Chinese farmers are now firmly converted to the Middle White cross on the local sow. Some are now maintaining their own stud boars and pure-bred sows, and they are venturing beyond the straight half-bred which until recently has been the most popular.

Poultry.

Distributions of Rhode Island Red birds and eggs were as follows:-

Cockerels, pullets and chicks	309
Eggs for setting	1,084

Selangor, Kelantan and Pahang show the greatest development, but all States and Settlements are planning to increase their foundation flocks. Demand is in excess of supply.

Resettlement Areas.

The resettlement areas are now well under way in all States and Settlements, and the agricultural problems arising out of this re-grouping are now being assessed and appreciated. This work has added considerably to the duties of the Field Branch and all officers are actively engaged in formulating and presenting schemes to assist the farmers during the

early stages of development and also for their long term welfare. These resettlement areas offer opportunities for assistance and planned development that hardly existed under the old scattered squatter system of farming. Stud centres for pure-bred boars can now be more effectively planned, and also the distribution of good poultry and budded fruit trees. Most areas are presenting proposals for pools of mechanical equipment and the new conditions are highly favourable for this important development.

PLATE I.

Bali Cattle.

A young bull.

PLATE II.

Bali Cattle.

Two heifers.

IMPORT OF BALI CATTLE INTO THE FEDERATION OF MALAYA

Before World War II, large numbers of Balinese cattle were imported into Malaya regularly from Indonesia and slaughtered on arrival, for beef. However, in early 1941, several thousand of these animals were imported as an emergency war-reserve as beef-on-the-hoof and they were distributed throughout the country, mostly to suitable coconut and rubber estates, where they thrived on the rough grazing and were, to all appearances, of benefit to the permanent crop. The majority of these animals were later slaughtered to deny them to Japanese invaders but a few escaped and at least two are still in use, in Perak, for draught purposes.

These domesticated *Banteng* are apparently well adapted for beef production in Indonesia and at the end of 1950 it was decided that this Department, in consultation with the Veterinary Department, should make an attempt to obtain breeding stock of these promising animals and, after prolonged negotiations, ten young animals were imported recently from Bali, comprising two young bulls and eight heifers. This small herd is now at the Federal Experiment Station, Serdang, where the animals will be multiplied for use in experiments on the diversification of smallholders' agriculture in this country.

These Balinese cattle differ from both European cattle (*Bos taurus*) and from Zebu cattle (*Bos indicus*) as they comprise a domesticated form of the *Banteng* (*Bos sondaicus*—also *Bibos sondaicus*). In appearance they more closely resemble a small seladang (*Bos gaurus*) than Malayan cattle of Indian origin. In colour, most of the young animals are brownish-buff but bulls and some of the older cows are much darker brown. Their mild expression is no way belies their docility as they are easy to handle and can be trained for haulage purposes.

It is a little too soon to say how these animals will fit into Malayan peasant agriculture but there is some evidence to suggest that they will thrive better in kampong conditions than milch cattle. They appear to require some browsing as well as grazing or cut fodder and they dislike the full heat of the sun at midday. In Bali and Lombok, where they are reared in large numbers, they are said to be fond of browsing on *Petai Jawa* (*Leucaena glauca*). At Serdang they have been found to like bunches of Jack fruit and *Tembusu* leaves such as are given to goats by Malayan smallholders. Perhaps the most important characteristic of Bali cattle is that they can be left out all night, as housing was found to be unnecessary for non-breeding animals in 1941.

Departmental Notes

New Year Honours.

Mr. A. de K. Frampton, Senior Agricultural Officer, who is on secondment as Agricultural Adviser to the Comptroller for Development and Welfare, West Indies, was awarded the C.M.G. in the New Year Honours List.

Appointments.

Mr. J. R. Curry, Senior Agricultural Officer, has been appointed to act as Chief Field Officer, with effect from the 9th November, 1951.

Mr. Gunn Lay Teik, O.B.E., who retired from the Service in May, 1951, has very kindly agreed to return from retirement to assist the Department in these times of shortage of qualified officers by accepting, on agreement, the post of Senior Chemist.

Mr. J. Chattaway, Agricultural Officer, ceased to act as State Agricultural Officer, Johore, and resumed duty as Agricultural Officer, Johore Central, with effect from the 9th November, 1951.

Leave.

Dr. W. N. Scott, Senior Agricultural Officer, returned from leave on the 8th November, 1951, and assumed duty as State Agricultural Officer, Johore.

Mr. E. J. H. Berwick, Senior Agricultural Officer, returned from leave on the 7th November, 1951, and assumed duty as State Agricultural Officer, Selangor.

Mr. P. G. Coleman, Agricultural Officer, returned from leave on the 8th November, 1951, and assumed duty as Agricultural Officer, Kedah.

Statistical

MARKET PRICES

October to December, 1951.

Rubber.—The average monthly Singapore price of No. 1 R.S.S., f.o.b., in bales, dropped by a little more than 17 cents per lb. during the last quarter of the year. The highest price in October was 159½ cents and the lowest 149½ cents per lb.; the average price for the month being 154.3 cents. In November there was a gradual decrease from 152¾ cents on the first day to 138¾ cents on the 30th, the average price being 145.27 cents per lb. There was a small increase in price during December but the average for the month was only 140.04 cents per lb.

The average prices paid for smallholders' rubber at three centres in the Federation of Malaya during the period under review are given in Table I.

Table I.
Average Monthly Prices Paid by Local Dealers for Smallholders' Rubber, October to December, 1951.
(Dollars per picul of 133 1/3 lbs.)

Grades	Taiping, Perak.			Seremban, Negri Sembilan.			Batu Pahat, Johore.		
	Oct.	Nov.	Dec.	Oct.	Nov.	Dec.	Oct.	Nov.	Dec.
Smoked Sheet	163.50	151.50	154.00	172.00	159.00	158.00	140.76	126.38	128.63
Unsmoked Sheet	140.00	127.50	131.00	143.00	133.00	131.00	131.25	116.25	120.00
Scrap	55.00	45.00	54.00	65.00	55.00	58.00	41.25	35.63	32.50

Transport from Batu Pahat to Singapore by lorry, excluding duty, $1.50 per picul.

Tea.—The only price for Malayan tea quoted in the Colombo Brokers' Association weekly reports issued during the last quarter of the year was that for the 16th October when the average price was Rs.1.78 per lb. In the same report, the prices quoted for Ceylon teas were, in rupees per lb.: High Grown Teas 1.93, Medium Grown Teas 1.73 and Low Grown Teas 1.90. The prices of Ceylon teas quoted in the report dated the 29th December were 1.91, 1.68 and 1.84 rupees per lb. respectively.

Derris.—The price of derris, as quoted in the weekly reports of the Singapore Chamber of Commerce, increased from $130 to $150 per picul during the period under review.

Tobacco.—The average prices per picul of cured leaf paid in Kelantan during the last quarter of 1951 were:—1st quality $733, 2nd quality $317 and 3rd quality $83.

Rice.—The ration of rice has remained at 3½ katis per person per week. The range of prices, in cents per kati, of the three grades of ration rice are as follows:—High Grade 32 to 36, Medium Grade 25 to 30, and Low Grade 19 to 21.

Table II.

Singapore Prices of Various Agricultural Products.

(Dollars per picul)

Date	Copra, Sundried	Coconut oil*	Pepper, F.A.Q. Muntok white	Pepper, Gen. Muntok white	Gambier, Cube	Sago Flour, Lingga	Tapioca Flour No. 1	Oilcake, Round
1951								
1st Oct. -	38.00	67.50	895.00	905.00	80.00	18.50	30.00	18.00
9th Oct. -	39.00	70.00	905.00	915.00	80.00	18.25	32.00	18.00
15th Oct. -	41.50	73.00	900.00	910.00	82.00	18.25	32.00	18.00
22nd Oct. -	44.50	76.00	855.00	865.00	82.00	18.00	33.50	19.00
30th Oct. -	41.00	73.00	825.00	835.00	85.00	18.00	33.50	19.00
5th Nov. -	38.50	68.50	780.00	790.00	83.00	17.75	34.00	19.00
12th Nov. -	37.50	67.00	715.00	725.00	82.00	17.75	34.50	19.00
19th Nov. -	37.50	66.50	835.00	845.00	82.00	18.00	36.00	19.00
26th Nov. -	36.25	65.00	775.00	785.00	85.00	18.25	37.00	18.00
3rd Dec. -	35.75	63.50	765.00	770.00	85.00	18.25	38.00	18.00
10th Dec. -	36.00	63.50	775.00	785.00	84.00	17.75	38.00	19.00
17th Dec. -	36.75	64.50	765.00	775.00	85.00	16.25	38.00	19.00
27th Dec. -	36.75	64.50	775.00	785.00	84.00	16.25	38.00	20.00

* F.O.B.

The above prices are taken from the weekly reports of the Singapore Chamber of Commerce.

FEDERATION OF MALAYA
PRODUCTION OF PALM OIL AND KERNELS.

(In long tons as declared by Estates)

Month	Palm Oil		Palm Kernels	
	1950	1951	1950	1951
January	3,959	4,068	896	1,178
February	3,643	3,510	970	970
March	4,861	3,821	1,184	1,196
April	4,918	3,732	1,249	1,083
May	4,433	4,260	1,086	1,258
June	4,226	3,295	1,070	968
July	4,361	3,249	1,070	901
August	4,586	3,913	1,193	1,061
September	4,085	4,614	1,095	1,257
October	4,859	4,854	1,234	1,338
November	4,697	4,495	1,168	1,333
December	4,543	4,463	1,227	1,325
Total	53,171	48,274	13,442	13,868

In December, 44 estates (planted area 91,711 acres) were in production out of a total of 52 oil palm estates (planted area 97,347 acres).

MALAYAN AGRICULTURAL EXPORTS, JULY-SEPTEMBER, 1951.

Product	Net Exports in Tons.			
	Year 1949	Year 1950	July-Sept., 1950	July-Sept., 1951
Arecanuts	5,607	14,867	1,363	2,066
Coconuts, fresh † ‡	21,971 †	36,917 †	2,288 †	7,709 †
Coconut oil ‡	60,504	56,046	11,957	19,714
Copra ‡	24,424 *	4,778	4,941	9,715 *
Copra cake	27,643 *	31,104 *	8,482 *	10,523 *
Gambier, all kinds	294	331	4	56 *
Palm Kernels	8,744	9,070	2,690	2,555
Palm Oil	55,211	50,638	17,865	9,355
Pineapples, canned	8,130	14,666	3,647	4,234
Rubber ¶	670,257 ¶	692,585 ¶	182,281 ¶	210,013 ¶
Sago,—flour	1,476	12,006	3,928	8,862
„ —pearl	3,477	1,664	503	702
„ —raw	1,316 *	15,693 *	5,591 *	6,768 *
Tapioca,—flake	737	1,098	373	22
„ —flour	278 *	2,782 *	800 *	498 *
„ —pearl	12,346	13,507	3,815	2,147
Derris	48	44	11	13
‡ Copra equivalent	74,334	96,591	24,417	22,474

¶ production (Federation of Malaya). † hundreds in number. * net imports.

FEDERATION OF MALAYA RUBBER PRODUCTION.

(In long tons, dry weight)

Month	Estates		Smallholdings (Estimated)		Total	
	1950	1951	1950	1951	1950	1951
January	35,237	29,482	26,618	26,588	61,855	56,070
February	27,297	26,519	22,797	22,468	50,094	48,987
March	27,789	30,591	21,834	28,000	49,623	58,591
April	26,667	24,470	21,376	22,005	48,043	46,475
May	30,870	24,227	24,334	20,124	55,204	44,351
June	31,196	28,141	23,296	24,498	54,492	52,639
July	34,547	27,286	30,348	21,097	64,895	48,383
August	33,316	27,330	27,104	24,500	60,420	51,830
September	30,323	26,293	26,643	20,733	56,966	47,026
October	32,256	27,622	30,414	22,509	62,670	50,131
November	30,138	26,690	28,476	20,502	58,614	47,192
December	36,217	29,305	33,492	22,900	69,709	52,205
Total	375,853	327,956	316,732	275,924	692,585	603,880
Total 1949	400,009		270,248		670,257	

This Table has been compiled from statistics published by the Registrar of Statistics, Federation of Malaya.

Smallholding production is estimated from purchases reported by dealers.

FEDERATION OF MALAYA

PRODUCTION OF COPRA, COCONUT OIL AND COPRA CAKE.

(in tons)

Month	Copra Production						Coconut Oil Production		Copra Cake (Poonac) Manufactured	
	Estates		Smallholdings (estimated)		Total		Oil Mills		Oil Mills	
	1950	1951	1950	1951	1950	1951	1950	1951	1950	1951
January	2,577	2,346	7,765	8,501	10,342	10,847	5,501	5,537	3,634	3,532
February	2,662	2,516	6,868	6,323	9,530	8,839	4,831	4,856	3,182	3,072
March	3,064	3,059	7,062	9,078	10,126	12,137	5,774	5,796	3,798	3,784
April	3,002	2,888	7,367	7,832	10,369	10,720	4,847	5,742	3,201	3,585
May	3,424	3,200	10,160	10,764	13,584	13,964	6,507	6,718	4,341	4,342
June	3,761	3,692	9,109	9,518	12,870	13,210	6,373	7,287	4,176	4,716
July	3,767	4,083	9,158	11,580	12,925	15,663	5,962	8,571	3,938	5,567
August	3,580	4,044	9,916	11,756	13,496	15,800	6,315	8,552	4,222	5,569
September	3,581	3,777	12,593	10,551	16,174	14,328	6,503	7,833	4,168	5,043
October	3,390	3,402	11,567	12,186	14,957	15,588	7,320	8,543	4,805	5,570
November	2,807	3,245	10,239	10,392	13,046	13,637	6,312	8,491	4,101	5,456
December	2,997	3,170	9,062	11,909	12,059	15,079	6,555	8,543	4,253	5,425
Total	38,612	39,422	110,866	120,390	149,478	159,812	72,800	86,469	47,819	55,661

Notes:—1. The above statistics are compiled and published by the Registrar of Statistics, Federation of Malaya.

2. Estate copra production and coconut oil production are as declared by estates and oil mills respectively.

3. Statistics of smallholding coconut oil production are not available.

4. Smallholding copra production for commercial purposes is estimated from the formula: imports + estate stocks (opening) + estate production + smallholding production = exports + local oil mill consumption + estate stocks (closing).

FEDERATION OF MALAYA

Padi Season 1951 - 1952.

Acreages of WET Padi Planted Monthly during 1951 and 1952 and Percentages of Total Planted Area.

State or Settlement	To October (2)		November (3)		December (4)		January (5)		Total (6)		Total Area Planted and to be Planted (Acres) (7)	Per cent. (8)
	Planted Acres	Per cent of (7)	Planted Acres	Per cent of (7)	Planted Acres	Per cent of (7)	Planted Acres	Per cent of (7)	Planted Acres	Per cent of (7)		
Perlis	41,572	86.2	6,626	13.7	6	.1	—	—	48,204	100.0	48,204	6.1
Kedah	254,348	90.7	19,743	7.0	6,343	2.3	42	—	280,476	100.0	280,476	35.3
Kelantan	66,465	46.4	59,250	41.4	14,645	10.2	610	.4	140,970	98.4	143,208	18.0
Trengganu	34,064	73.0	9,047	19.4	3,544	7.6	—	—	46,655	100.0	46,655	5.9
Penang and P. Wellesley	20,093	51.7	14,505	37.3	4,276	11.0	—	—	38,874	100.0	38,874	4.9
Perak	68,395	70.9	21,743	22.5	4,943	5.1	1,465	1.5	96,546	100.0	96,546	12.1
Selangor	1,249	2.2	19,075	33.7	9,666	17.1	15,364	27.2	45,354	80.2	56,533	7.1
Pahang	23,828	94.1	1,473	5.8	20	.1	—	—	25,321	100.0	25,321	3.2
Negri Sembilan	26,763	96.4	885	3.2	110	.4	6	—	27,764	100.0	27,764	3.5
Malacca	19,683	66.6	5,791	19.6	3,754	12.7	318	1.1	29,546	100.0	29,546	3.7
Johore	1,136	74.2	249	16.3	74	4.8	61	4.0	1,520	99.3	1,531	.2
Total	557,596	70.2	158,387	19.9	47,381	6.0	17,866	2.2	781,230	98.3	794,658	100.0

FEDERATION OF MALAYA

Padi Season 1951 - 1952.

Total Acreage of WET and DRY Padi Planted and to be Planted.

State or Settlement	WET PADI		DRY PADI	TOTAL Wet and Dry Padi
	Planted by 31st January, 1952 (acres)	Total Planted and to be Planted (acres)	Total Planted and to be Planted (acres)	Area Planted and to be Planted (acres)
Perlis	48,204	48,204	87	48,291
Kedah	280,476	280,476	2,368	282,844
Kelantan	140,970	143,208	28,776	171,984
Trengganu	46,655	46,655	8,152	54,807
Penang and P. Wellesley	38,874	38,874	61	38,935
Perak	96,546	96,546	473	97,019
Selangor	45,354	56,533	—	56,533
Pahang	25,321	25,321	1,010	26,331
Negri Sembilan	27,764	27,764	27	27,791
Malacca	29,546	29,546	3	29,549
Johore	1,520	1,531	5	1,536
Total	781,230	794,658	40,962	835,620

METEOROLOGICAL SUMMARY, MALAYA, NOVEMBER, 1951.

Locality	Air Temperature degrees Fahrenheit							Earth Temperature		Rainfall								Bright Sunshine		
	Means of			Absolute Extremes						Total		Most in a day	Number of days					Total	Daily Mean	Per cent.
	A. Max.	B Min.	Means of A and B	Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	At 1 foot °F	At 4 feet °F			Amt.	Precipitation .01 in or more	Precipitation .04 in or more	Thunderstorm	Fog morning obs.	Gale force 8 or more			
										ins.	m m.	ins.						hr.	hr.	
Ipoh, Perak	91.2	72.9	82.1	94	71	88	75			10.44	265.2	1.46	25	21	2	1		189.65	6.32	
Port Swettenham, Selangor	89.0	72.9	80.9	93	71	86	74	83.9	85.0	9.02	229.1	1.39	21	20	4	2		196.52	6.55	
Kuala Lumpur, Selangor	89.9	73.3	81.6	93	71	84	75			22.31	566.7	4.56	25	22	9	7				
Sitiawan, Perak	89.4	73.5	81.5	93	72	86	75	85.1	85.9	7.11	180.6	2.15	19	16		1		190.06	6.33	
Kuala Lipis, Pahang	89.5	72.2	80.9	92	70	87	74	84.3	84.8	17.83	452.9	3.68	25		1	30		182.69	6.09	
Kuantan, Pahang	88.9	72.4	80.7	92	70	84	75			12.84	326.1	1.99	20	20	2	8		188.05	6.27	
Temerloh, Pahang																				
Bayan Lepas, Penang	87.7	74.7	81.2	90	73	85	77			11.56	293.6	3.45	22	18	2			224.42	7.48	
Malacca	86.7	73.9	80.3	90	71	85	76			6.01	152.7	1.26	20	15	2		1	244.89	8.16	
Mersing, Johore	87.4	72.3	79.9	91	70	82	74			9.46	240.3	3.67	14	12	1			227.80	7.59	
Alor Star, Kedah	88.5	73.7	81.1	92	71	84	76			17.99	456.9	6.46	22	19				217.05	7.23	
Kota Bharu, Kelantan	86.2	74.6	80.4	89	73	80	76	84.4		12.44	316.0	6.18	22	17	2	3		178.10	5.94	
K. Trengganu, Trengganu	86.3	73.3	79.8	89	72	83	74			6.64	168.7	1.17	19	17		7		208.50	6.95	
Kallang Aerodrome (S'pore)	88.3	74.8	81.5	91	73	85	77			7.34	186.4	1.65	15	15	5			193.00	6.43	
HILL STATIONS.																				
Fraser's Hill, Pahang 4268 ft.																				
Cameron Highlands, Tanah Rata, Pahang 4750 ft.	72.9	56.8	64.9	76.9	53.2	69.1	63.3	68.8	69.9	20.11	510.8	1.88	28	28				114.00	3.80	

Compiled from Returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, DECEMBER, 1951.

Locality	Air Temperature degrees Fahrenheit							Earth Temperature		Rainfall									Bright Sunshine		
	Means of			Absolute Extremes						Total		Most in a day	Number of days						Total	Daily Mean	Per cent.
	A. Max.	B. Min.	Means of A and B	Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	At 1 foot °F	At 4 feet °F			Amt.	Precipitation .01 in or more	Precipitation .04 in or more	Thunderstorm	Fog morning obs.	Gale force 8 or more				
										ins.	mm.	ins.							hrs.	hrs.	
Ipoh, Perak	90.3	73.1	81.7	93.8	69.3	83.8	75.3			6.32	160.5	1.80	19	15	4		2		168.50	5.43	
Port Swettenham, Selangor	88.5	72.8	80.7	92.3	70.1	80.8	74.7	84.1	85.0	14.41	366.0	1.99	20	19	6	2			167.40	5.40	
Kuala Lumpur, Selangor	89.4	73.3	81.3	94.7	70.2	82.4	75.3			4.83	122.7	1.10	21	17	4	6					
Sitiawan, Perak	89.1	73.4	81.3	92.2	70.5	85.5	75.0	84.9	85.9	6.45	163.8	1.94	15	14	2	3			153.14	4.94	
Kuala Lipis, Pahang	86.5	72.3	79.4	91.6	70.0	76.8	74.9	83.5	84.3	7.50	190.5	1.27	21	22	3	27			133.28	4.30	
Kuantan, Pahang	85.1	72.4	78.7	89.8	68.6	80.4	74.2			31.49	799.8	6.05	25	21	1	1			111.00	3.58	
Temerloh, Pahang																					
Bayan Lepas, Penang	88.0	75.1	81.5	91.1	72.0	85.7	77.0			3.72	94.5	1.78	11	8	3				197.87	6.38	
Malacca	86.9	73.6	80.3	89.7	70.3	82.0	75.2			5.43	137.9	1.24	16	14					178.69	5.76	
Mersing, Johore	83.6	73.9	78.7	88.6	72.4	80.0	78.2			19.81	503.2	7.92	22	20	2				148.05	4.77	
Alor Star, Kedah	88.6	72.7	80.7	91.7	69.4	85.8	75.3			4.83	122.7	2.70	13	10					216.06	6.97	
Kota Bharu, Kelantan	83.6	74.3	78.9	86.1	70.0	77.0	76.3	81.2		20.34	516.6	5.92	27	22		1			124.95	4.03	
K. Trengganu, Trengganu	83.2	73.4	78.3	85.8	70.0	77.1	77.0			21.39	543.3	8.66	27	25			1		133.35	4.30	
Kallang Aerodrome (S'pore)	87.3	74.2	80.7	91.6	71.4	83.0	76.6			10.58	268.7	2.60	20	14	7		1		145.00	4.68	
HILL STATIONS.																					
Fraser's Hill, Pahang 4268 ft.																					
Cameron Highlands, Tanah Rata, Pahang 4750 ft.	71.8	58.5	65.1	74.1	50.8	68.3	63.2	66.8	68.8	6.30	160.0	0.89	22	22					104.15	3.33	

Compiled from Returns supplied by the Malayan Meteorological Service.

METEOROLOGICAL SUMMARY, MALAYA, JANUARY, 1952.

Locality	Air Temperature degrees Fahrenheit							Earth Temperature		Rainfall								Bright Sunshine		
	Means of			Absolute Extremes						Total		Most in a day	Number of days					Total	Daily Mean	Per cent.
	A. Max.	B. Min.	Means of A and B	Highest Max.	Lowest Min.	Lowest Max.	Highest Min.	At 1 foot °F	At 4 feet °F			Amt.	Precipitation .01 in or more	Precipitation .04 in or more	Thunderstorm	Fog morning obs.	Gale force 8 or more			
										ins.	m m.	ins.						hr.	hr.	
Ipoh, Perak	91.6	72.3	81.9	94.2	68.9	85.6	75.3			8.68	220.5	1.70	15	12	2			225.65	7.28	
Port Swettenham, Selangor	88.9	72.3	80.6	92.2	69.0	80.1	74.7	83.1	84.5	7.18	82.4	1.34		16	5	1		161.65	5.21	
Kuala Lumpur, Selangor	89.6	72.6	81.1	94.0	70.0	79.0	75.1			4.16	105.7	1.37	15	12	1	5				
Sitiawan, Perak	89.5	72.9	81.2	92.0	69.8	86.0	74.9	84.4	85.3	5.33	135.4	1.87	12	12	4	1		194.95	6.29	
Kuala Lipis, Pahang	85.9	71.5	78.7	89.3	69.0	78.6	73.8	82.6	83.4	7.08	179.8	0.98	22	21		27		150.60	4.86	
Kuantan, Pahang	84.6	72.1	78.3	88.1	66.6	79.2	75.4			11.35	288.3	2.51	24	20				127.20	4.10	
Temerloh, Pahang	87.0	71.3	79.0	91.4	68.0	75.2	73.6			7.54	191.5	2.62	17	17		2		164.60	5.31	
Bayan Lepas, Penang	88.8	74.4	81.6	91.4	71.7	85.1	77.1			3.01	76.5	1.26	6	5	2			249.75	8.06	
Malacca	86.5	73.5	80.0	91.6	71.8	74.6	75.6			8.50	215.9	5.40	11	10			2	159.70	5.15	
Mersing, Johore	82.3	75.3	78.8	84.2	70.0	79.1	77.9			20.45	519.4	11.29	21	17			4	123.15	3.97	
Alor Star, Kedah	90.3	71.3	80.8	95.1	65.4	85.7	74.1			1.59	40.1	1.12	6	5				267.50	8.63	
Kota Bharu, Kelantan	84.7	74.3	79.5	87.3	66.1	80.7	78.5	82.9		0.84	21.3	0.27	10	6		2		198.50	6.40	
K. Trengganu, Trengganu	83.5	73.9	78.7	86.0	66.6	80.1	77.0			1.71	43.4	0.51	23	10		3		178.45	5.76	
Kallang Aerodrome (S'pore)	85.7	74.4	80.1	90.8	72.4	78.4	76.2			15.24	387.1	2.87	20	17	1			122.05	3.94	
HILL STATIONS.																				
Fraser's Hill, Pahang 4268 ft.	68.6	60.1	64.3	73.4	57.1	64.1	63.2	70.9	71.5	9.92	252.0	1.68	26			25		78.25	2.52	
Cameron Highlands, Tanah Rata, Pahang 4750 ft.	71.0	58.8	64.9	75.9	52.4	66.4	63.7	66.5	68.4	5.03	127.8	2.55	18	18		1		135.45	4.37	

Compiled from Returns supplied by the Malayan Meteorological Service.